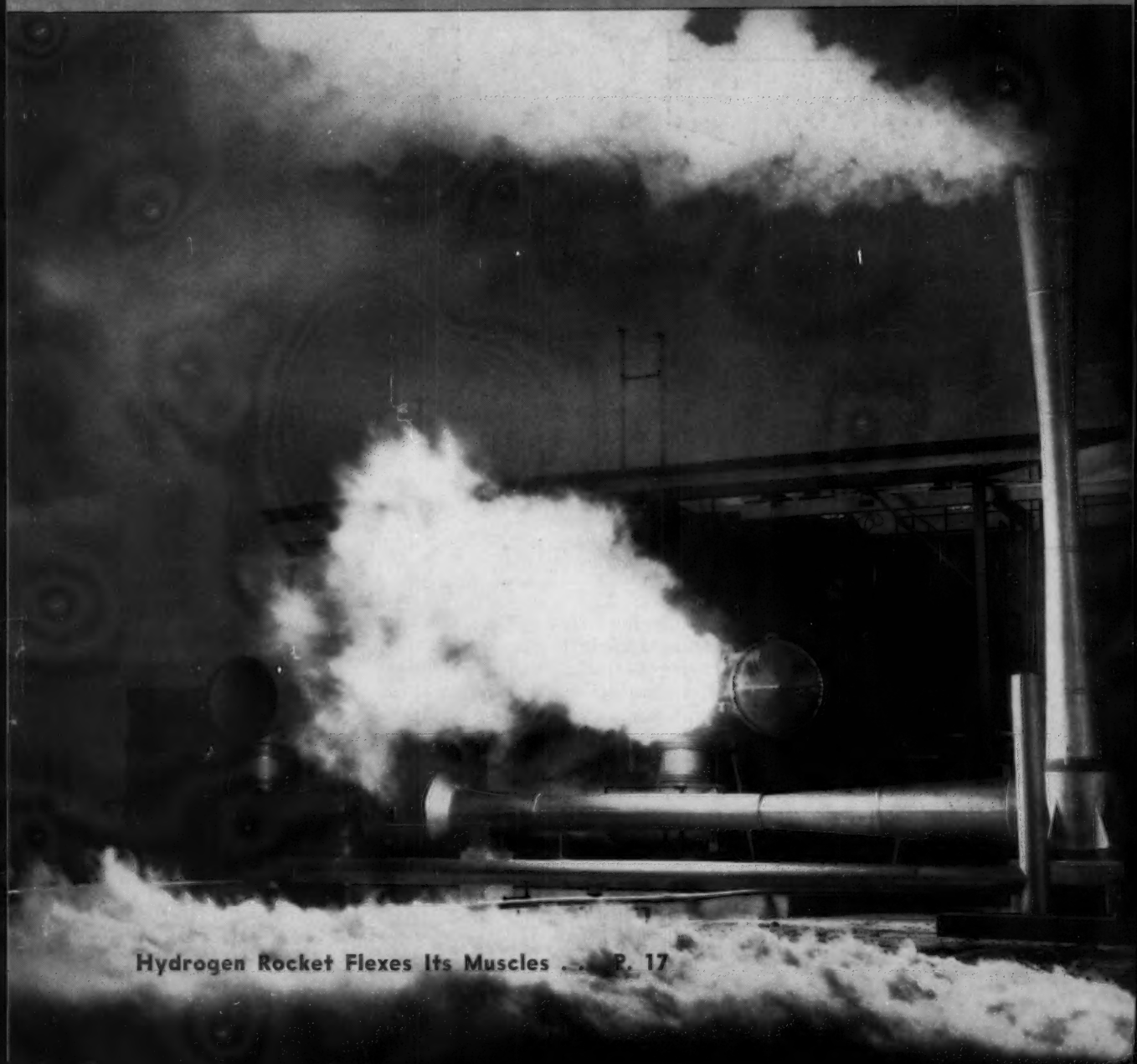
AIRCRAFT & MISSILES

Chilton Publication APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES October 1960

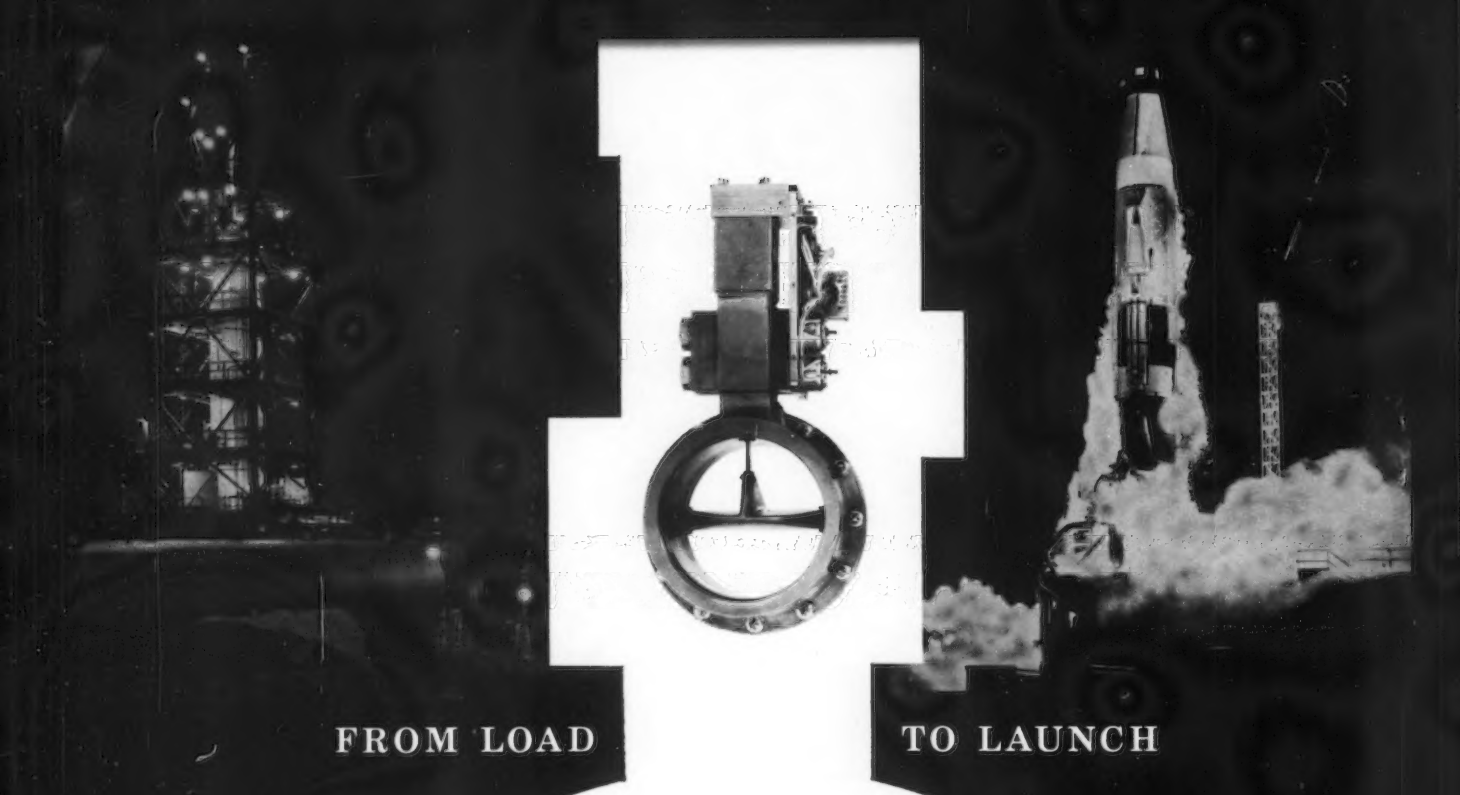
How to Design for High-Temp Insulation . . . P 40

CHALLENGE AND PROGRESS – SPACE NAVIGATION . . . P 28

Engineer the Environment for Sensitive Electronics . . . P 22



Hydrogen Rocket Flexes Its Muscles . . . P. 17



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October, 1960 *Volume 3, Number 10*

AIRCRAFT & MISSILES

APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES

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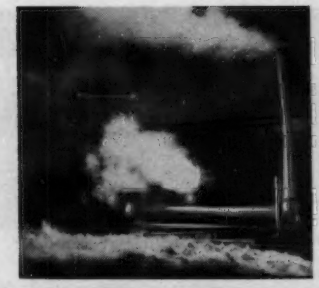
THE COVER STORY

Flame of LR-115 hydrogen rocket engine bursts from diffuser of a test stand during a night firing. Scene is the Everglades at Pratt & Whitney Aircraft's Florida Research and Development Center. At top of picture is steam from ejector stack. At bottom of picture, vapors from liquid oxygen hug the ground. Two such engines will power Centaur space vehicle in 1961. See page 17.



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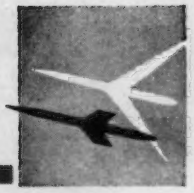


EDITORIAL

Legalized Counterfeiting?

You build it—if it falls apart, someone else gets the blame. Nice way to operate? Yet, this is what can and does happen with present government procurement policies.

One case in point. Prominent airframe maker designed and built landing gear parts for large bombers. Drawings were picked up by DOD and farmed out for bids. One large supplier to the industry, who entered the bid competition, went over the prints and the military requirements carefully—very carefully.

Thorough checking disclosed that the original maker's nameplate was to be copied without change. Yes, even **the airframe maker's name was to appear as the manufacturer** of the landing gear part. The name of **the proposed new supplier was not to be stamped on the nameplate.**

Phones jangled, two presidents got their heads together to squash this ridiculous military requirement. It wasn't bad enough to have the drawings sent out for bid when the airframe company had shop capacity, but to have the parts counterfeited seemed like the last straw. At any rate, this case was stopped. How many have not been stopped?

Do you want to be put into the position of having someone paid to do work that you originated and then you get the blame for their mistakes? This can readily happen. Surely, if that landing gear had failed, the immediate blame would have gone to the airframe company. Few may read the subsequent investigation. Think, such an occurrence could ruin the reputation of an innocent party.

Let's take another case. This one concerns a proprietary process.

A large firm designed and built a piece of special equipment for oxygen regulation in military aircraft. The company spent its own money to develop the unit and to develop a special brazing technique to put it together. DOD said that this was great, just what they needed. So, DOD picked up the plans and asked for bidders. What DOD didn't pick up was the special brazing process—this was proprietary. According to regulations, there is no need to include proprietary processes on defense specs. Only trouble, no special process—no reliability. Result, one fogged cockpit.

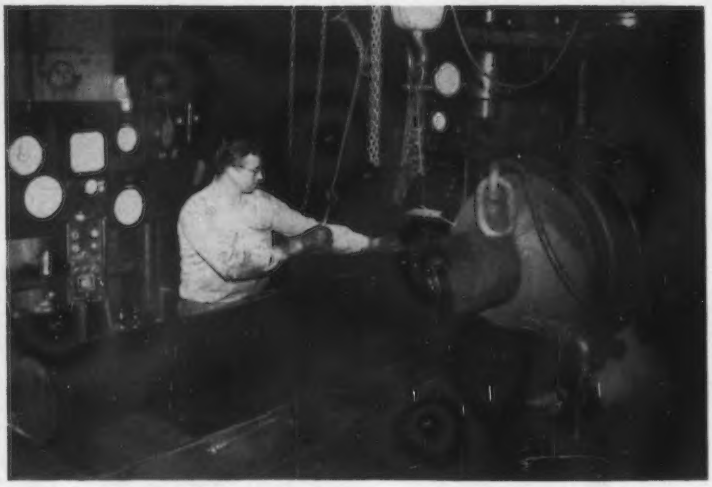
It seems that DOD decides that items should go out for bid without regard for reliability. Then more money can be poured into the program to work backward instead of going forward to achieve vitally needed progress.

If you have case histories, with proof, of vicious procurement practices, let us know about them. Aircraft & Missiles will continue its efforts to help small and big business in seeking fair procurement policies.

Tom MacNew

Editor

What MORE Do You Want GRAPHITE To Do For You?



Graphite has been useful in aircraft and missile problem-solving as a component material in rocket motors, in brazing fixtures for airframe construction, and in other refractory applications.

Further and more advanced uses of graphite in space age progress may well be developing now as part of your design engineering program.

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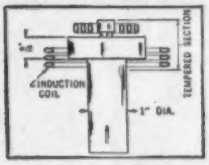
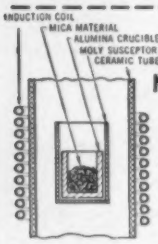
TYPICAL INDUCTION HEATING APPLICATIONS



Punch Heads Selectively Tempered

Diagram shows arrangement for selectively tempering heads of alloy steel punches. The use of a combination type solenoid and pancake induction coil reduces hardness from Rc 55/56 to Rc 41/44, improving resistance to brittle fracture at the head of the punch. In this case a heating cycle of 55 seconds provides uniform tempering. A multiple position fixture, processing 4 pieces at one time, speeds up production.



Heating Non-Conducting Materials To High Temperatures

Laboratory analyses frequently require heating of non-conducting materials to temperatures of 3,000 to 3,500° F. in vacuum or special atmosphere. This can be accomplished by induction heating with the aid of a metal susceptor. Diagram shows the fusion of mica samples in an alumina crucible, using molybdenum susceptor. A ceramic tube surrounding the susceptor isolates the work for fusion in a vacuum. The molybdenum susceptor is heated by induction, which in turn, heats the crucible by radiation.

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Reader's Orbit

A Critic's Critic

. . . Your August editorial "More Mobility—Less Publicity" strikes us as a bit of irresponsible fence straddling.

Editorial material must be very scarce when a Chilton Publication with the stature of AIRCRAFT & MISSILES decides the time is right to take a poke at the people engaged in publicizing our defense efforts. Surely A & M is aware that as a defense industry trade book its responsibility goes beyond the mere transmission of technical data and at times encompasses the promotion of new defense concepts. Only through the cooperation of the trade books such as A & M can word of new developments be spread to the various interested segments of the industry and the public at large, only through publication of new ideas can the industry grow.

Granted, we would all like to see more armament in the various areas of today's weapon system, but this is the matter for the Military and Congress to decide (sic), not the company with an idea they wish to promote in the interest of National Defense.

William F. Hurley
Product Advertising Manager
American Machine & Foundry Co.

Trade and business magazines make America's technical and management leaders the most informed in the world. This is because they evaluate, rather than promote projects and concepts.

Chilton Research

. . . have read with interest the article entitled: "Man-Machine Space Complex," by W. S. Wilson in the July issue of Aircraft & Missiles. May we have a reprint of this article? Also, members of our Human Factors Laboratory would like to correspond with Mr. Wilson. To this effect may we have his company address?

John W. Chaffee
Anthropometrist
Human Factors Lab.
Convair — Ft. Worth

We are happy to say that Mr. Wilson is a member of our parent company, Chilton Co. He is now a candidate for a doctorate in anthropology. Mr. Wilson is a part of our rapidly growing Research Dept., which serves Chilton's own 18 magazines and also does work for outside organizations.

Fast and Factual

. . . just completed the Supervisor and Planners Course on the Atlas missile. When I returned, my August issue of Aircraft & Missiles was waiting . . . The article on APCHE (Checking The Operational Atlas, page 21) was exceptionally well done . . . Have sent my copy to the Air Force School at Sheppard AFB, Texas and suggested they use it in the training course. This article does, in brief, what is needed (to understand) this complicated system.

Edmund W. Edmonds, Jr.
Lt. Col., USAF
Headquarters 8th Air Force

Ryan's Tolerance

. . . In August you published an article entitled "ANIP Gives Birth" . . . the author stated that dimensional tolerances of 0.02 in. are held using explosive forming techniques . . . We think this should read 0.002 in. tolerances as we are currently forming our parts to this. We commend you on your publication . . . we find the articles of great value.

R. G. Shevlin, Chief
Mfg. Research and Development
Ryan Aeronautical Co.

We think you are entirely correct. Our own "printing tolerances" are also more stringent than this typographical error indicates.

Aeronca's Speedbrake

. . . The article by John Kushnerick on the A2F airplane was indeed very interesting (ANIP Gives Birth, August 1960). However . . . The speedbrake for the airplane is A286 material which is a stainless steel . . . this speedbrake is, to our knowledge, the first application of this specific material to airframe requirements . . . brake is subjected to temperatures up to 1100°F and operates in an acoustical environment of approximately 155 db.

H. C. Pettit, Manager
Sales Promotion
Aeronca Mfg. Corp.

New Books

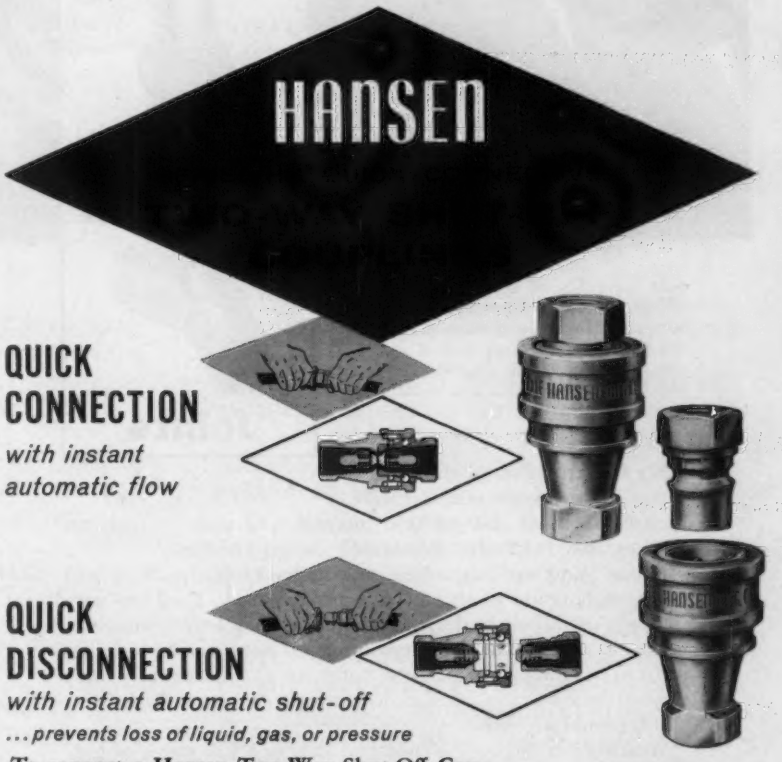
TECHNICAL COMMUNICATION. By George Harwell. Macmillan, 1960. 332 pp., $5.00. Athough written primarily as a textbook for engineering students, this book is intended to fill the practicable needs of technical writers in general. Fundamental principles and basic types of writing are discussed in a direct style; typical examples are given in each case amplified with explanatory notes. Subject matter covered includes: an analysis of effective writing, organization of material, methods of exposition, business letters; general, formal and informal reports, technical articles, oral communication, illustrative material, and general composition. A basic list of abbreviations for scientific and engineering terms, compiled by the American Standards Association, is also included. A manual of general composition, at the end of the book presents some of the most common pitfalls of the English language.

HANDBOOK FOR SPACE TRAVELERS. By Walter B. Hendrickson, Jr. Bobbs-Merrill, 1960. 256 pp., $3.95. This book is written for the youthful space fan pondering on the wonders of outer space and the rockets that will take him there some time in the future. Chapters are grouped under five topical areas as follows: Tools of space exploration; history of rockets; rocket bases; the future of rockets; and where to go in space.

AIRCRAFT AND MISSILES. By D. M. Desoutter. De Graff, 1959, 213 pp., $7.50. The general reader and the aerospace enthusiast seriously interested in this exciting field will find here much on the "what" and "how" of it. The form of presentation used is not intended to be profound; instead, readability and explicitness have been stressed. The material covered extends from the atmosphere, to methods of propulsion, types of aircraft and missiles, physical and medical aspects of aviation, research, experiment, development, etc. Included are also separate chapters on records, organizations, glossary of terms, and aircraft designations.

INGENIOUS MATHEMATICAL PROBLEMS AND METHODS. By L. A. Graham. Dover, 1959, 237 pp., $1.45. This is a collection of contributions to "Private Corner for Mathematicians" conducted by the author for the past 18 years in the "Graham Dial." Prime purpose of this book is to delight those having "a Yen for things mathematical." Contents include 75 provocative problems, 25 challenging quickies, and an assortment of mathematical nursery rhymes. Answers are provided in the last portion of the book.

FOUNDATIONS OF AERODYNAMICS. Second edition, by A. M. Kuethe and J. D. Schetzer. Wiley, 1959, 446 pp., $11.75. This is a revamped and updated edition without departing from the authors' original objectives "to present in a form suitable for classroom use, the foundations on which aerodynamics rests." The fundamentals of the flow of perfect, compressible, and viscous flows are treated in 16 chapters; an expanded appendix section contains problems from each chapter, graphical material, charts, and tables.



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Your Datebook

September 27-30
Space Power Systems Conference
American Rocket Society
Miramar Hotel, Santa Monica, Calif.

October 3-5
National Midwestern Conference on Air Logistics
Institute of the Aeronautical Sciences
Tulsa, Okla.

October 5-7
"Opportunities in Space-Age Technology"
American Management Assn.
Hotel Astor, New York, N. Y.

October 6-8
Symposium on Omni-sonic Flight
Society of Experimental Test Pilots
Ambassador Hotel, Los Angeles

October 10-14
National Aeronautic Meeting
Society of Automotive Engineers
Ambassador Hotel, Los Angeles

October 12-14
Seventh National Symposium
The American Vacuum Society
Cleveland-Sheraton, Cleveland, O.

October 14-15
15th Midwest Conference
American Society for Quality Control
Broadview Hotel, Wichita, Kan.

October 19-21
Symposium on Space Navigation
Institute of Radio Engineers
Deshler-Hilton, Columbus, O.

October 20-21
National Symposium on Hypervelocity Techniques
Institute of the Aeronautical Sciences
Shirley-Savoy, Denver, Colo.

Data Capsule

SUMMARY OF MANAGEMENT TRENDS AND TECHNICAL DEVELOPMENTS IN THE AEROSPACE INDUSTRIES

MISSILES AND SPACE VEHICLES

Design

1500-MILE POLARIS will be 30 in. longer than current model, which has 1200-mile range. New version will have improved rocket motors with more propellant in first stage and a higher energy propellant in second stage. Polaris may have 2500-mile range within four years by use of new fuel, lightweight casing, and thrust vector control nozzles replacing jetavators. This "Super Polaris" will require larger launch tubes than those used in the first five atomic subs.

ADVANCED NIKE ZEUS DESIGN is "canard" type. Control fins are on forward portion rather than aft. Tests under tactical conditions take place in the South Pacific.

SERGEANT NOSE CONE is designed to give U. S. a capability in any chemical as well as nuclear war.

ADVANCED THORS will be delivered by Douglas to Air Force and NASA for scientific programs. Engines produce 165,000 lb thrust. These Thors plus Agena B second stage can orbit 1250 lb payload.

PROJECT APOLLO, next step in manned spacecraft beyond Project Mercury, is now in the design study phase. NASA's Space Task Group is directing. Bidders' proposals are due this month. Studies are to be completed by May.

METEOROID BUMPERS are under study at General Electric. This is a construction in which "skin" is protected by shields spaced one inch away. In tests, tiny pellets bombard an aluminum block shielded by .063-inch 1100T-24 aluminum.

Development

MINUTEMAN is now expected to be ready for three-stage flight tests by December. Prototype guidance control system will be tested this Fall at Holloman AFB.

WEAPONS SYSTEM T-238, now in Army use, fires 45 chemical-warfare rockets in rapid salvos. Developer: Arthur D. Little Inc.

LUNAR CAPSULE RETRO-ROCKET will be developed by Hercules Powder Co. at Bacchus, Utah. Ryan Electronics will supply the altimeter. Firms were awarded subcontracts by Aeronutronic, building a 300-lb instrumented package to be impacted on the moon within two years.

HYDRAULIC HOIST SYSTEM for Minuteman is under development at Bendix Corp. System is being tested at a 62-ft-deep simulated launch silo at the North Hollywood plant. Placing Minuteman in its underground launcher tube involves 67 steps.

THE VICKERS "VIGILANT," British anti-tank missile, is nearing the end of development tests. Trials with the infantry begin in a few months. System weighs 45 lb.

MAULER is being considered by the Navy and The Marines for anti-aircraft anti-missile use on landing vessels.

BLUE WATER, new British missile, is being developed by the British Aircraft Corp. It is listed as medium-range, tactical, surface-to-surface.

NUCLEAR PROPULSION OFFICE will be run jointly by NASA and the AEC to consolidate the work of both agencies in developing nuclear energy for space missions. Immediate effect: integration of Project Rover nuclear rocket work.

Production

HERCULES POWDER CO. will produce the third-stage rocket engine for Minuteman.

STENTOR ROCKET ENGINE is in quantity production at Bristol Siddeley. It will power Blue Steel, the stand off bomb being developed by Avro.

HIGH SPEED MILLER is cutting engine fabrication time at Rocketdyne by about 50 per cent. It is a numerically-controlled Kearny & Trecker with tolerance accuracy of plus or minus 0.001.

Procurement

LARGER PROCUREMENT in the offing for missile and aircraft hardware to give the U. S. more offensive capability in chemical and biological warfare. Would only be used in retaliation.

AIRCRAFT

Design

VARIABLE CAMBER PROP is being developed by Hamilton Standard for the Navy. Six or eight blades are mounted in sets of two on a common hub. Rear blades are staggered behind the front ones. To change camber, prop would automatically alter the angles at which front and rear blades meet the air.

FIRST MODIFIED ELECTRA begins FAA tests next month. Engine mountings and power package are being strengthened at cost of about $25-million.

TYPE "117" is paper design for a low-cost, subsonic airliner proposed by Handley Page. Model would have tailless configuration along with low-drag, boundary-layer suction.

Development

XLR99 FLIGHT TESTING in the X-15 is beginning. This new powerplant has 57,000 lb thrust. Predecessor, the XLR11, had 16,000 lb thrust, pushed X-15 to world speed and altitude records. Reaction Motors has put XLR99 through over two hours steady operation in ground environmental tests.

VANGUARD 2C vertical lift aircraft will have a Lycoming T53 gas turbine for further wind-tunnel tests. Next step after this may be actual flight tests. Ryan Aircraft is meanwhile reported accelerating work on its fan-in-wing model.

TWO PROTOTYPES of low drag boundary layer control aircraft are being built by Norair Div., Northrop Corp. LD-BLC reduces air drag as much as 80 per cent. Prototypes are expected to be ready within two years. Intensive environmental test program is slated. Wings will have long thin intake slots along entire length to reduce air friction.

VTOL LIFT FAN was recently exhibited by GE's Flight Propulsion Lab, which says present thrust-to-weight ratio of 9-to-1 can be increased to 15-to-1 by 1965.

T72-T-2 TURBOSHAFT engine begins performance testing this month. It is 500-hp Continental Aviation model with vertical installation features.

MACH 20 hypersonic wind tunnel will be installed at the Aeronautical Research Lab, Wright Field. It will be designed and fabricated by FluiDyne Engineering Corp.

BRITISH NAVY is ordering new Airstream Direction Detector System for its aircraft. Developed by Ferranti Ltd. and Specialties Inc., it provides continuous angle of attack information.

NEW RESEARCH AIRCRAFT produced by Handley Page is called "115." It will investigate the low speed behavior of slim delta types.

Production

FIRST TURBOFAN-POWERED B-52H is due to leave the assembly line at Boeing-Wichita this month. Deliveries to SAC begin early next year.

FIAT FACTORIES in Italy have special flooring of wooden blocks with grain running vertically. This is covered with a thin tar-like substance. Setup minimizes chances of engine parts being damaged from dropping.

F-105D THUNDERCHIEF has completed over 20,000 miles of "hands-off" automated test flying. Autopilot is integrated with the all-weather navigational and fire control system. Pilot can take off in ceiling-zero weather, fly "blind" to the target. Fire control system automatically drops bomb and then rolls plane into normal altitude for escape.

MINUTEMAN TEST TRAINS grind to halt. Fourth and final train pulled in several weeks ahead of time. SAC then ended this test program, which originally called for six deployments. SAC cited "substantial savings" to taxpayers.

Procurement

SPECIAL ARMY BOARD has reviewed requirements for the 1960-70 period. Among its objectives: a suggested procurement program for future types of aircraft. The board has placed increased emphasis on a new light observation aircraft, and on V/STOL research aircraft.

The Aerospace M·A·P

This capsule of business developments and trends is part of Aircraft & Missiles' Marketing Assistance Program, a research service to aid companies in the aerospace market.

DEFENSE EXPENDITURES AND NEW ORDERS

The graphs on this page are based on actual Department of Defense dollars allotted for new orders and on dollar expenditures. For trend projection, the graphs show a three months' moving average index. Civil aircraft data are presented on the following page. Charts shown here are for defense dollars only and are categorized as follows:

Aircraft

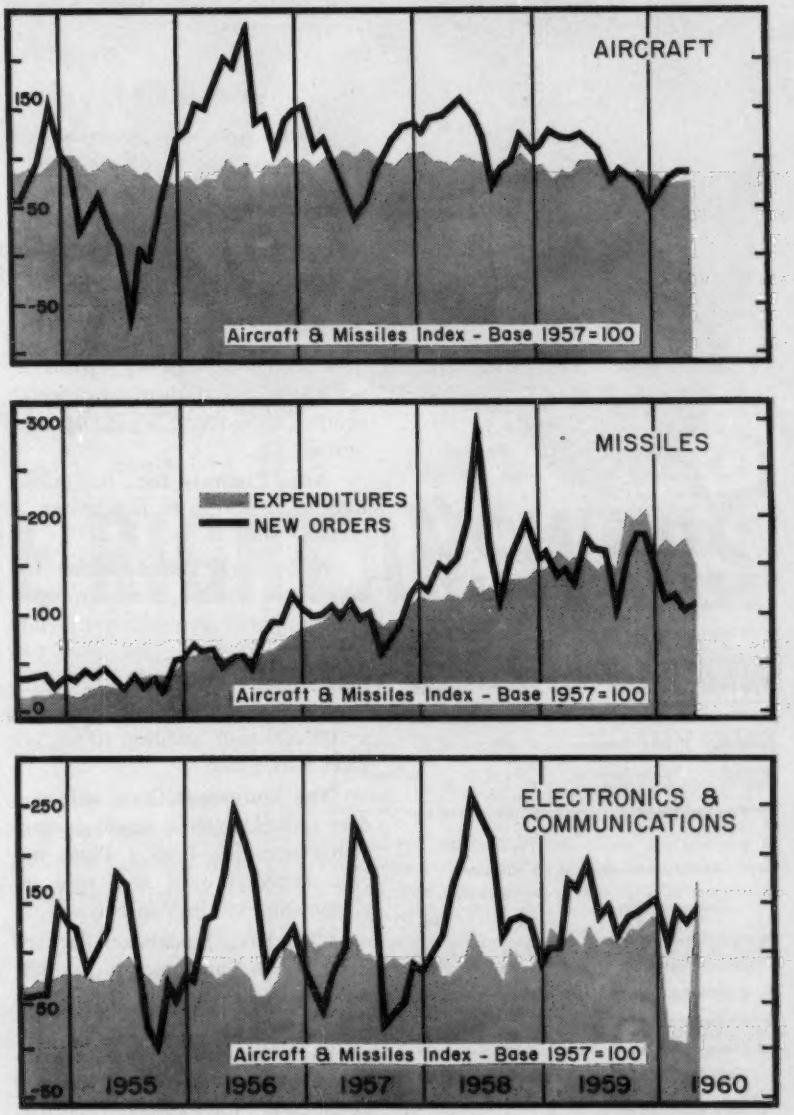
This category includes airframes, engines, armament, electronics, and other government furnished equipment. Also included are spares, special tools, test equipment, and ground handling equipment.

Missiles

The missile graph includes complete missile systems—armament, launching, guidance, control, boosters, sustainers, propellants, special tools, and ground handling equipment.

Electronics and Communications

Graph is related to the following equipment: radar, electromagnetic equipment, computers, radiation aids, countermeasures, radiac and infrared, meteorological equipment, sonar, transmission or reception units, noise and interference detection devices, test equipment, spares, and related component equipment.



Index based on 3-month moving average

Key:
Solid line = New Orders
Shaded area = Expenditures

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of this data can be obtained by writing on company letterhead to The Editor, AIRCRAFT & MISSILES, Chestnut & 56th Sts., Phila. 39, Pa.

The Aerospace MAP

NUMBER AND VALUE OF CIVIL AIRCRAFT SHIPMENTS

Month	Units 1960	Units 1959	Value (000,000) 1960	Value (000,000) 1959
January	747	665	$96	$50
February	855	619	113	50
March	867	736	90	34
April	768	745	127	68
May	802	759	131	81
June	694	779	110	65
July	.....	630	....	88
August	.....	647	....	95
September	.....	432	....	76
October	.....	739	....	104
November	.....	705	....	77
December	.....	786	....	112
Year	.....	8,242	....	$900
6 Mos.	4,733	4,303	$667	$348

SHIPMENTS OF PISTON ENGINES FOR CIVILIAN AIRCRAFT

Month	Units 1960	Units 1959	Value (000,000) 1960	Value (000,000) 1959
January	1,025	873	$2	$3
February	1,039	954	3	3
March	1,141	921	3	3
April	1,064	947	2	3
May	894	921	2	2
June	772	979	2	3
July	.....	844	....	2
August	.....	747	....	2
September	.....	804	....	2
October	.....	1,051	....	4
November	.....	1,060	....	4
December	.....	1,051	....	4
Year	.....	11,152	....	$35
6 Mos.	5,935	5,595	$14	$16

NET SALES (In Millions)

Product and Type of Customer	Six Months 1960	Six Months 1959
Complete Aircraft and Parts		
For U. S. Military Customers	$1,725	$2,036
For Other Customers	897	606
Total—Aircraft and Parts	$2,622	$2,642
Aircraft Engines and Parts		
For U. S. Military Customers	$480	$693
For Other Customers	223	175
Total—Engines and Parts	$703	$868
Aircraft Propellers and Parts		
For U. S. Military Customers	$42	$28
For Other Customers	14	20
Total—Propellers and Parts	$56	$48
Total—U. S. Military Customers	$2,247	$2,757
Total—Other Customers	$1,134	$801
Other Products and Services	$2,187	$1,824
Total—All Products	$5,568	$5,382

BACKLOG OF ORDERS (In Millions)

Product and Type of Customer	June 30th 1960	June 30th 1959
Complete Aircraft and Parts		
For U. S. Military Customers	$4,168	$5,009
For Other Customers	1,884	2,507
Total—Aircraft and Parts	$6,052	$7,516
Aircraft Engines and Parts		
For U. S. Military Customers	$1,009	$1,296
For Other Customers	328	487
Total—Engines and Parts	$1,337	$1,783
Aircraft Propellers and Parts		
For U. S. Military Customers	$52	$55
For Other Customers	7	15
Total—Propellers and Parts	$59	$70
Total—U. S. Military Customers	$5,229	$6,360
Total—Other Customers	$2,219	$3,009
Other Products and Services	$4,543	$3,519
Total—All Products	$11,991	$12,888

Business Moves

General Instrument Corp. and General Transistor Corp. have merged; General Instrument is the surviving firm.

Avco Corp. is changing the name of its Crosley Div. to the Avco Electronics and Ordnance Div. Avco's Research and Advanced Development Div. has formed a new Industrial Products Subdivision to market products primarily in the areas of high-temperature technology and environmental simulation.

Facilities

North American Aviation now runs a new "hot shot" wind tunnel at its Missile Div. It triggers air currents up to Mach 20.

Associated Testing Laboratories will open two new labs next Spring; in the Boston and Los Angeles areas.

Sperry Rand Corp. plans to occupy a new "advanced research center" at Sudbury, Mass., by mid-Spring.

Atlas Controls, Inc., has moved into a 12,000-sq-ft new plant at Natick, Mass.

AiResearch Manufacturing Co. announced that it has been operating a remote cryogenic test facility near Boron, Calif., for over two years.

Sperry-Utah recently dedicated a 108,000-sq-ft addition to its Salt Lake City plant.

The Marquardt Corp. will conduct radiation-effects research associated with the Project Pluto nuclear ramjet project at a new environmental lab in Van Nuys.

CTL Div., Studebaker-Packard Corp., will manufacture missile components at a new Santa Ana, Calif., plant.

Ryan Aircraft now has a high-energy-forming facility at Kearney Mesa, Calif., for shaping Space Age metals.

Boeing Airplane is constructing a "Minuteman launch complex" next to the Boeing Developmental Center in Seattle. Complex is for testing the complete weapon system. Though it includes silo, it will not be used for any actual firings. Boeing is now occupying a new $2,250,000 lab for basic research.

Vertol Div., Boeing Airplane Co., plans to build a $2-million engineering research and test facility in Phila., Pa.

Contracts

North American Aviation — $168.5-million for additional production of the A3J-1 Vigilante at the Columbus Div.

Lockheed Missiles and Space Div.—$78-million from the Air Force Ballistic Missiles Center to continue development of a communications system for data readout and satellite control in Discoverer, Samos, and Midas.

General Electric Co.—$21-million to the Large Jet Engine Dept. from the Air Material Command for the J79 turbojet.

Sylvania Electric Products—$6-million from the Air Force for inter-site communications systems at the Atlas missile bases at Warren AFB and Schilling AFB.

Douglas Aircraft — $5½-million for further quantity production of MB-1 Genie rockets.

Minneapolis-Honeywell Regulator Co.—$2.9-million from the Bureau of Naval Weapons for additional Asroc production.

Beech Aircraft—$3-million for additional Model 1025 missile targets.

General Electric Co.—$2,400,000 to discover and develop materials and methods for producing high-reliability capacitors for Minuteman guidance; $1,247,000 to the Ordnance Dept. to fabricate advanced design inertial guidance systems for Polaris.

Thiokol Chemical Corp. is prime on a $500,000 Air Force-sponsored study to provide nuclear propulsion system data to contractors. Work will take place at firm's Nuclear Development Center, Parsippany, N. J.

Before Buying Any Valve

ASK THESE QUESTIONS

1. Will It Perform More Effectively In The Service?
2. Where Will It Save Money?
3. How Practical Is The Design?

jamesbury "Double-Seal"™ BALL VALVES*

As Versatile As Industry Itself!

PROVIDE THE RIGHT ANSWERS

1. The "Double-Seal" Ball Valve has PROVED more effective in handling a wider range of liquids and gases than any other valve.
2. The "Double-Seal" Ball Valve requires no lubrication. Special design permits valve stem to be removed for repacking while valve remains in line full-open or full-closed. Resulting savings on maintenance are significant.
3. The "Double-Seal" Ball Valve design is the original ball valve design engineered to give more control, full pipeline capacity and minimum friction loss.

JAMESBURY CORP., Worcester, Mass.

Distributors in Principal Cities

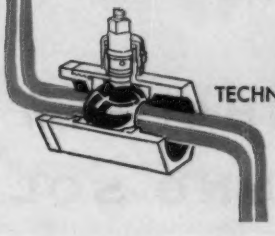
Widest Range of Sizes and Materials Available

METAL VALVES		PLASTIC VALVES	
TYPE	SIZES	TYPE	SIZES
Screwed End	¼" thru 3"	Screwed End	½" thru 3"
Flanged	½" thru 10"	Flanged	½" thru 4"

Jamesbury "Double-Seal" Ball Valves are available in Types 303, 316 and Alloy 20 Stainless Steels, Carbon Steel, Bronze, Ductile Iron, Aluminum and PVC. Other materials on special order.

Interchangeable seats and seals are available in "Teflon", Nylon, Buna-N, Neoprene, Hypalon and natural rubbers.

Pneumatic, Hydraulic and Electric Motor Operators to fit Remote Control Requirements.



COMPLETE TECHNICAL INFORMATION ON REQUEST

* PATENTED

313-O

North American's highly versatile A3J Vigilante is an all-weather aircraft with atomic fire-power capability. Chatham designed and supplies the 28VS200BL silicon power conversion equipment which furnishes the dc power. There are two units on every A3J, each delivering 200 amps.

Chatham Transformer-Rectifiers specified for NORTH AMERICAN A3J Vigilante

The North American two-place, twin-jet A3J Vigilante is an all-weather attack weapon system which can be carrier or land based. The A3J was designed to deliver a wide variety of ordnance, including nuclear weapons, at either high or low altitudes at speeds in the Mach 2 range.

Naturally this broad-base capability and strategic application make rigid standards of reliability and performance of A3J equipment mandatory. For this reason, North American chose Chatham conversion equipment to furnish the dc power with unfailing dependability. Electronics aboard the A3J and the nature of the aircraft's intended use makes it imperative that a very constant reliable source of dc power is always available. Chatham's 28VS200BL transformer-rectifier met the rigorous electrical requirements fully while keeping size and weight to a minimum. The 28VS200BL weighs less than 16 pounds, stands 5″ high, is 7″ wide, and only 11″ long.

North American adds still another important name to the list of aircraft and missile manufacturers who count upon Chatham design and manufacturing know-how to deliver the best in airborne power conversion equipment. This unmatched top-performance reliability in highly compact packages results because Chatham maintains complete control of every step in production including the manufacture of its own solid-state components. By strictly controlling size and shape of each component, Chatham achieves the most efficient configuration while meeting the toughest electrical specifications.

Send for Folder T-26. It describes Chatham power supplies. Many are immediately available. Or forward your specifications. We'll gladly recommend the design that will do the best job for you. Chatham Electronics, Division of Tung-Sol Electric Inc., Livingston, N. J. TWX: LVTN NJ-489

CHATHAM . . . ***world's leading supplier of airborne power conversion equipment.***

CHATHAM ELECTRONICS
division of
TUNG-SOL ELECTRIC INC.

Cryogenic Hydrogen Progress

Vacuum firings of Centaur engines highlight liquid H_2 rocket-tests at Pratt & Whitney; Materials technology, handling techniques evolve

By John P. Kushnerick

Liquid hydrogen flows colder and burns hotter than any other liquid rocket fuel. It is also the lightest fuel and packs the greatest specific impulse punch. The engine to put these properties to work has been built and delivered to Air Force. It is Pratt & Whitney's LR-115. Sometime next year it will power the upper stage of Centaur on its first space mission.

An up-rated version of the engine is already being developed for the upper stages of Saturn and later Centaurs. This engine is called LR-119.

Environmental Testing—A major phase of bringing the liquid hydrogen engine to reality has been the testing of materials, components, and systems under conditions closely simulating their operational environments. Conditions of heat (5500°F), cold (—423°F), and space (near vacuum).

More than 8-million gallons of liquid hydrogen have been produced, pumped, and consumed at P & W's Research and Development Center. Handling problems of the cryogenic fuel have been ironed

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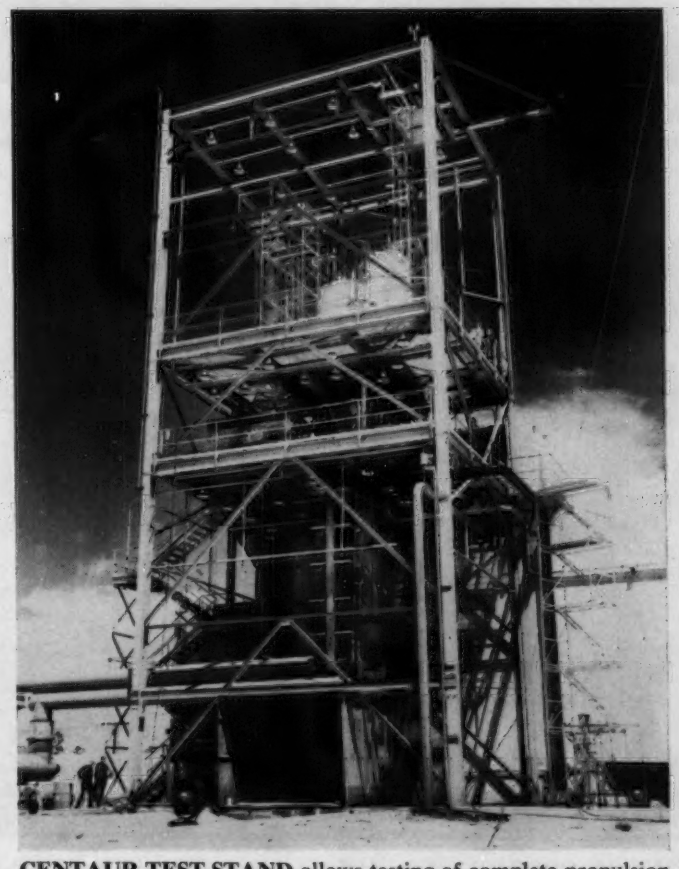
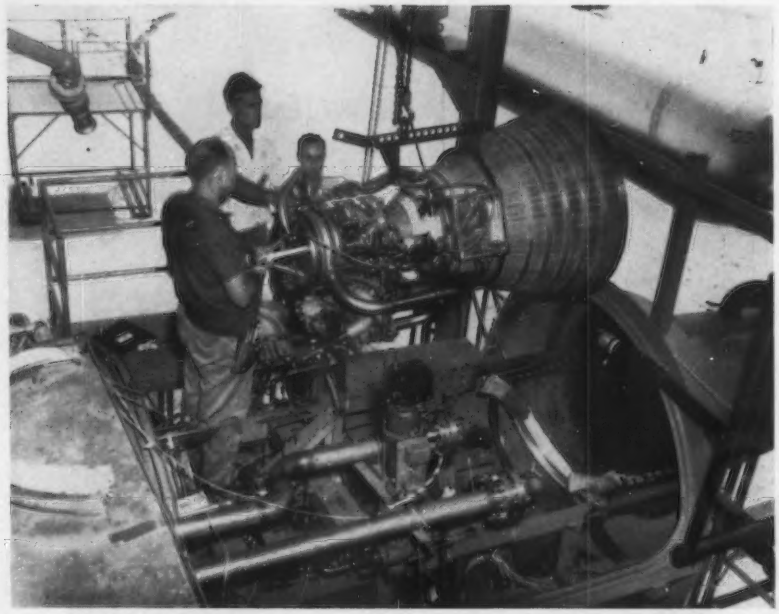
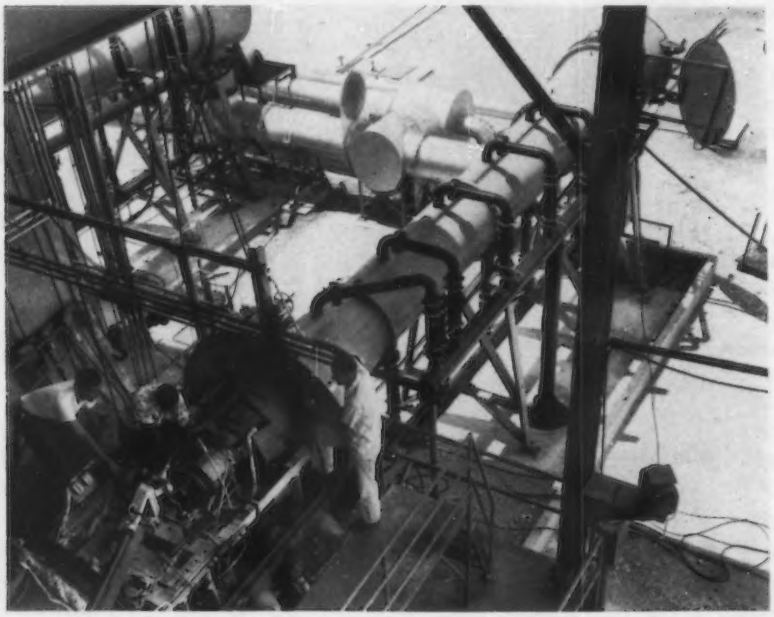


CENTAUR TEST STAND allows testing of complete propulsion system under simulated space conditions. Two LR-115 engines are suspended beneath liquid hydrogen and liquid oxygen tanks.

Transport vehicles and feed lines for cryogenic fuel all vacuum-jacketed



SPACE ENVIRONMENT for testing liquid hydrogen engine at Pratt & Whitney-Florida is supplied by "vacuum tank." Engine is shown being lowered into position with sliding tank cover removed.



ENGINE IN POSITION shows diffuser which maintains near vacuum during firing run. Chamber is made of carbon steel because this material conducts heat away rapidly. Dark pipes carry water into cooling jacket.

out. (Air Products Inc. operates the plant which produces liquid hydrogen from crude oil.)

Five full-scale rocket engine test stands and 15 specialized stands are in use developing the LR-115 and LR-119.

In full-scale tests the engines are actually fired in partial vacuum. This is to study light-off and burning conditions experienced in space.

A steam ejector and supersonic diffusers produce this environment. The engine is sealed inside an evacuated tank and fired into the diffuser. The steam ejector provides the vacuum environment for engine start. A door at the aft end of the diffuser acts as a seal to maintain the vacuum. When the engine is fired, the pressure rise in the diffuser blows open the door and the high speed gases exhausting through the diffuser maintain near-vacuum conditions at the nozzle.

A noteworthy phenomenon in the LR-115 is that the outside walls of the regeneratively-cooled combustion chamber run cold (—100°F), while a 5500°F-inferno rages within.

Handling Cryogenics — Present liquid hydrogen engines use liquid oxygen as an oxidizer. Both are supplied to test stands from large Dewar-type transport trailers. All fuel lines are also vacuum jacketed to maintain a temperature of at least —423°F at the propellant pump. Higher temperatures cause evaporation loss through boiling.

Engine tests are conducted with cryogenic propellants supplied directly from the transport trailers at pressures between 30 and 70 psi. Thrust chamber tests require that the propellants be delivered at conditions simulating normal engine operation in space. This means, the hydrogen entering a thrust chamber cooling jacket must be at a pressure

of approximately 1000 psi and near liquid temperatures. The liquid oxygen must also be supplied at pressures well above those allowed by conventional transportable tanks. High pressure, insulated supply tanks are, therefore, a part of the test-stand propellant-supply systems.

For safety, handling of liquid hydrogen requires a somewhat different approach than normal fuels, such as RP-1, or even other common cryogenic fluids such as liquid oxygen. All tanks, transfer lines, valves, and even instrumentation must be thoroughly purged of air and moisture prior to introduction of hydrogen. This is necessary to prevent freezing of contaminants in valves and controls. At –423°F, the temperature of liquid hydrogen at sea level pressure, all other materials (except helium) become solid. Successive purges of dry nitrogen and hydrogen gas are used prior to admitting liquid hydrogen to the test equipment.

Venting—In spite of vacuum jackets and perlite filler in storage tanks and pipe lines, some heat leakage occurs. Liquid hydrogen is then lost through vaporization. To prevent pressure build-up, all tanks and lines must be vented. A slight positive pressure on vents prevents entrance of air. Vent "overflow" is connected to vertical stacks where the escaping hydrogen is safely burned.

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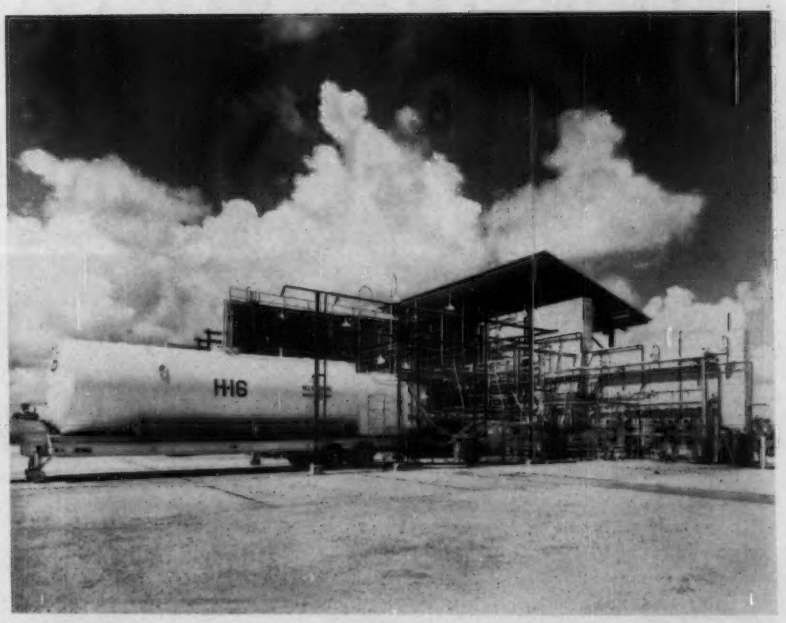
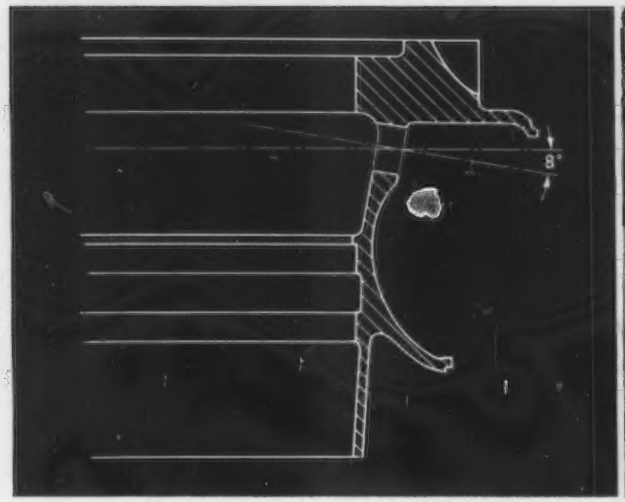


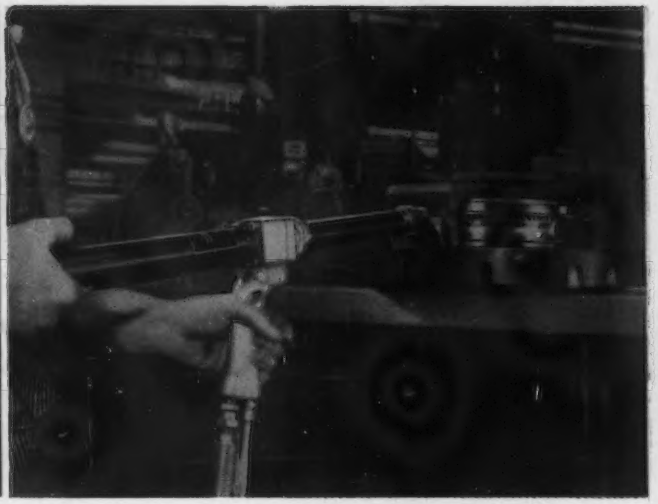
LIQUID HYDROGEN tank supplies 5000 gal of fuel for rocket tests. Tank is transportable. Vacuum insulation cuts evaporation. Feedlines are also vacuum insulated.

TELEVISION MONITORING of all hot runs is effected from control center. Cameras located at strategic points can give inside view of sealed vacuum tank.

How one aircraft parts subcontractor solved a tough production problem



Sectional drawing showing the inclination of hole at 8° to center line. Center lines of holes are required to be true within .010".



Close-up of Broach Gun, jig and fixture, showing ease of operation.

PROBLEM: MAKE 90 HOLES .281" SQUARE IN 13" DIAMETER STAINLESS STEEL RING TO ±.005" TOLERANCE

SOLUTION: USE CP PORTABLE BROACH GUN AND AN INEXPENSIVE FIXTURE

B. H. Aircraft Co., Inc., of Farmingdale, N. Y., is making a missile engine thrust chamber component for a major engine manufacturer. The problem of producing such close tolerance square holes could have been a major stumbling block. However, by using a CP Portable Broach Gun and a simple jig and fixture, these components are being produced in quantity with ***never a reject!***

Right: Broaching operation at B. H. Aircraft Co., Inc., showing simple jig and fixture. The portability of the CP Broach Gun and its self-contained Power Cell makes this an easy one-man operation.

Chicago Pneumatic *8 East 44th Street, New York 17, N. Y.*

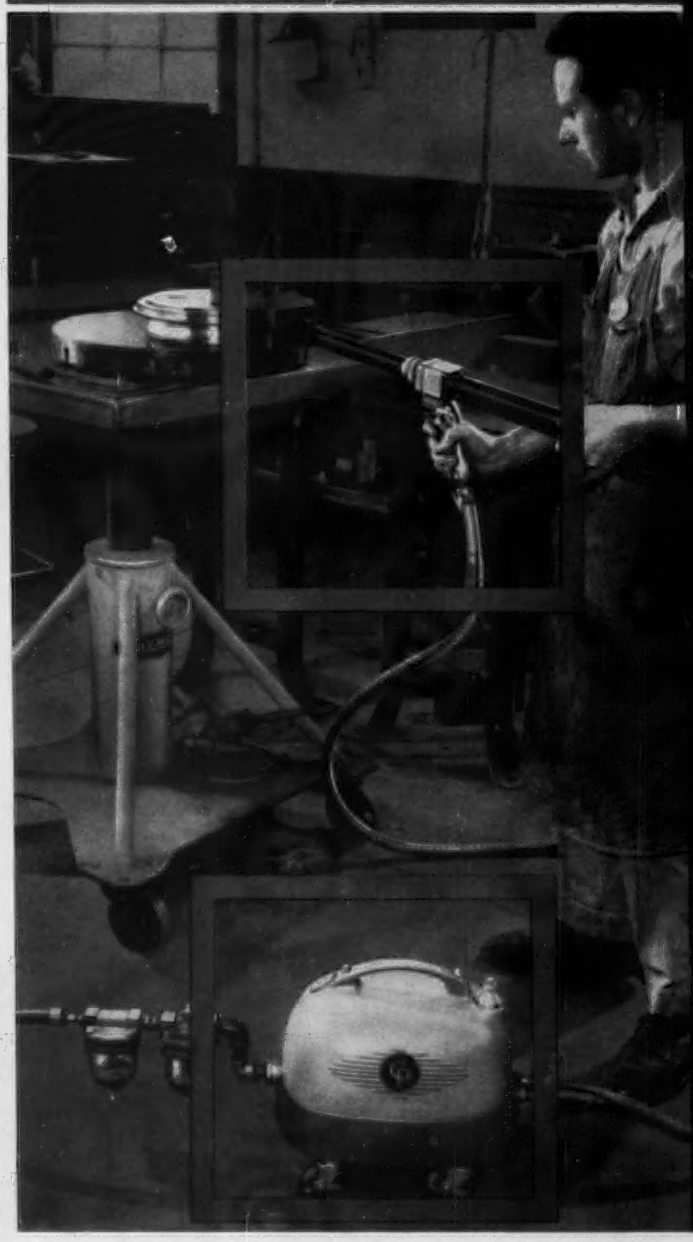
PNEUMATIC TOOLS • ELECTRIC TOOLS • AIR COMPRESSORS • DIESEL ENGINES • HYDRAULIC TOOLS • AVIATION ACCESSORIES

Completed part, with broach used to finish holes to .281" square.

Here are some of the things you can do with the NEW CP Portable Broach Gun

CONVERT ROUND PILOT HOLES TO THESE SHAPES:

- SQUARE
- HEX
- OVAL
- SPLINED
- KEYED

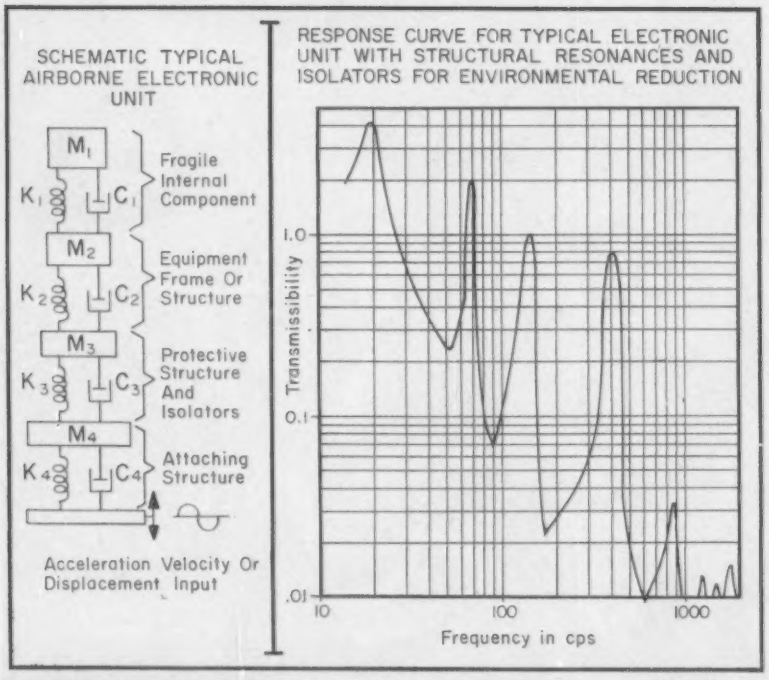


Using the CP Portable Broach Gun gives you a completely new technique in broaching. You take the tool to the work. Broach is inserted in round pilot hole and one squeeze of the trigger forms and finishes the hole. The broach pulls a clean, "mirror" finished hole, every time to ± .0002" accuracy. Self-contained CP Power Cell weighs only 58 pounds, operates on shop air lines and furnishes oil pressure up to 7,000 psi.

Engineering An Environment For Sensitive Electronics

"Finger snap" is extreme environment for unprotected target-sensing gear of Hawk; Good design techniques in "black-box" housing reduce battle field conditions to "still, quiet."

By Richard P. Thorn, Supervisor
Electronics Group, Lord Mfg. Co.



DESIGN REQUIREMENTS for typical electronic units in extreme environments can be divided into two broad categories: (1) Materials compatibility; (2) complete analysis of dynamic and static responses of entire system. Springs masses, dampers make up typical system. Each spring-mass-damper combination represents a single degree of freedom which reacts with other elements in the complex.

Aircraft and missiles components must deliver reliable performance under extreme environmental conditions. Radical techniques have evolved to protect them. Typical environmental extremes involve:

- Vibration
- Shock
- Noise
- Acceleration
- Climate

Vibration—Mechanical or structure-borne disturbances covering a frequency spectrum from 5 to 5000 cps, and including steady state sinusoidal, transient, and random excitations are called vibration.

The lower frequency region from 5 to 60 cps involves large displacement inputs typically 0.036 to 0.12 in d.a. and possibly as high as 1 in. d.a. The high frequency region from 60 to 5000 cps is usually associated with a constant acceleration as high as 20 G. Transient disturbances usually occur in systems where there is a shift from

one state of equilibrium to another. These disturbances are most often low frequency in character and decay rapidly. Random disturbances are the result of non-periodic forces producing a haphazard pattern of amplitudes at many frequencies over a particular band width. Typical random disturbances usually range from 0.05 to 0.2 G^2/cps over the band from 5 to 2000 cps. Such typical vibratory disturbances may occur independently or in any combination. This results in a dynamic environment much more severe than found in such specifications as MIL-E-5272 and MIL-E-5400.

Shock—Abrupt mechanical disturbance, shock, results from launching, maneuvers, gust loads, landings, atmospheric and water-reentry, and other types of impacts. Typical loadings may range up to 100 G with pulse durations from one millisecond to one second and pulse shapes such as half sine, triangular, shifted cosine, ramp, and Fourier spectrum.

Noise—This is an air-transmitted disturbance usually produced by a high energy jet or rocket exhaust. Sound pressure levels of 150 to 170 db are typical for near field jet exhausts. This excitation is usually random in nature and can result in severe structural disturbances previously classified under vibration.

Sustained Accelerations—Relatively long duration inertial forces result from the acceleration of masses in a system. Forces may range as high as 25 to 50 G and are usually superimposed on vibration or noise disturbances. Such loads are usually considered as a static condition.

Qualification Testing—To predict the ability of the system to withstand operational environments, accelerated life tests are required. These involve complex and rigorous qualification of each component, sub-system, and complete system. Such tests are usually more severe than the expected environment. They allow for a margin of safety and adequate operational reliability in the end use of the device.

Climatic Conditions—Other environmental and climatic conditions usually affect the choice of material. They are represented by such tests as salt spray or corrosion, temperature cycling, humidity, immersion, barometric pressure, moisture resistance, thermal shock, life at elevated temperature, explosion, sand and dust, fungus, and nuclear radiation.

The combination of high performance and extreme environments requires the best possible design technique. The casual design which results in less than top performance is not tolerable. Systems design must then be based upon a thorough analysis of static or ultimate loads, dynamic response, and environmental characteristics of the system. This would include the equipment and any means of protection incorporated. Important considerations are:

(1) The response characteristics of the attaching structure or the expected static and dynamic loads at the attachment points.

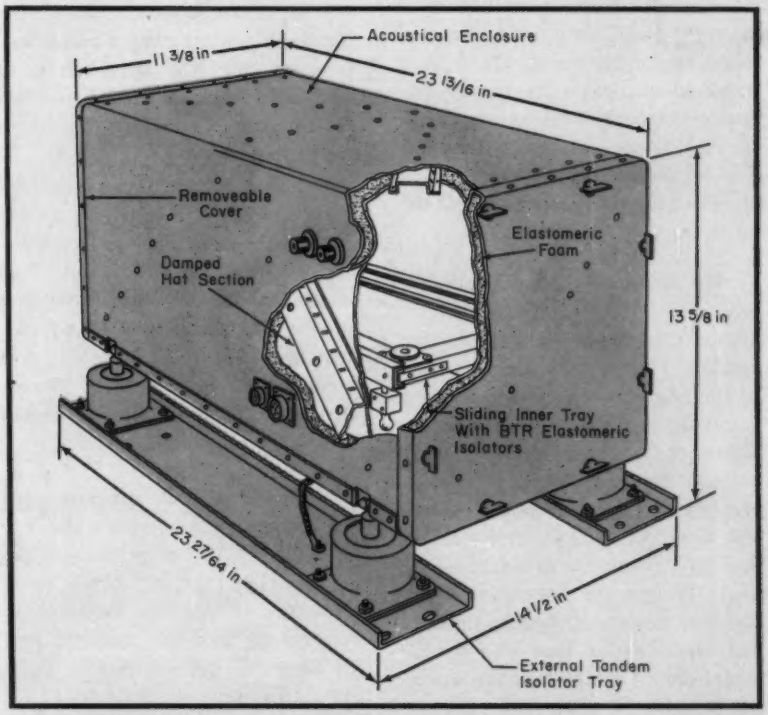
(2) The response characteristics of the mounting structure.

(3) The response characteristics of the individual isolator components including elastic damping and snubbing characteristics.

(4) The response characteristics of the mounted equipment including any components or sub-assemblies within the device. This is usually presented as a fragility envelope for the equipment.

(5) Material requirements to meet expected environmental conditions.

By satisfying these requirements, an adequate total system can be designed. Several approaches are available to the designer of electromechanical devices subjected to extreme environments.



ULTRA-SENSITIVE EQUIPMENT for Hawk weapon system is protected from extreme environments by enclosure that incorporates "Dyna-damp" structural sections. Lord Mfg. redesigned this box cutting approx. 100 lb from overall weight, and $700 from overall cost.

"Casual" design not tolerable in electronics; thorough systems analysis essential

Ruggedization—This approach is a method of modifying or improving a design by adding structural strength or stiffness at critical points to eliminate fatigue or component failure. It may also include changing of material or component arrangement to improve life. The goal of ruggedization is to produce a part which has a fragility envelope in excess of any expected input disturbance. This approach usually results in a weight increase.

Dynamic Tuning—This alternative involves properly selecting the various system natural frequencies. The aim is to space natural frequencies far enough apart to eliminate additive interaction between elements of the same system, usually a minimum of one octave spread is required. Another method is to raise the basic natural frequency of any component above the highest expected excitation frequency. Dynamic tuning is akin to ruggedization in that increasing a system natural frequency usually results in a stiffening or ruggedization of the structure.

Reducing of Amplification—Reduction of resonant amplification amounts to adding damping to the system. This may be accomplished by the addition of interface or joint damping extensional or surface treatment, or high modulus elastomeric damped structural configurations. Resonant amplifications and resultant dynamic stress levels may be reduced by as much as 20 to 1 through the use of effective damping treatment. System stiffness and ruggedization may also be accomplished if a high modulus material is used.

Removal or Reduction—Relocation of the electronic device to a quieter area or by introducing suitable protective means to reduce the disturbance is another design consideration. Since any complex structural assembly, such as a missile or aircraft, has a multitude of structural natural frequencies, the amount of disturbance in any particular region or zone will depend upon the location of that zone with respect to the major source of excitation. Usually the further the zone is from the excitation or engine area, the lower are the disturbances. A full understanding of the vehicular environment and the various vibratory levels will allow the design engineer to take advantage of the inherent response characteristics of the primary structure. Further reduction of the input excitation may be obtained by use of unit isolators, a complete mounting system, or an acoustical shield, depending upon the type of excitation. In each case, the approach is to take advantage of the attenuation or filtering characteristics of a spring mass system.

Mass reduction is a design approach which will result in an increase in system natural frequency and, in effect, a ruggedization. This is associated with miniaturization and/or modularization of component assemblies. The result is also a ruggedization because of the increased stiffness usually associated with smaller assemblies.

Materials—Each material used must be compatible with the environmental and strength requirements of the design. Many good reference sources are available to help select both the material and the allowable strength limits. Typical sources are:

(1). "Handbook of Instructions for Aircraft Designers."

(2). "Handbook of Instructions for Missile Designers."

(3). "Strength of Metal Aircraft Elements," "MIL Handbook—5."

(4). "Materials and Process Specifications," "U. S. A. F. Specification Bulletin 23."

(5). "A Cross-Index of Chemically Equivalent Specifications and Identification Code—Ferrous and Non-Ferrous Alloys MIL Handbook H1A."

Application of Principles—Application of these design principles is shown in the following example. The system is required to protect a sensitive piece of electronic equipment in an extreme environment. The design provides vibration, shock, and noise protection for a stabilized local oscillator (STALO) used in Raytheon Co.'s Hawk. The environment includes such requirements as satisfactory operation under tactical battlefield conditions, bombardment, nuclear blast and missile launching. The equipment must be capable of being transported over rugged terrain without deterioration of capabilities and arrive at the destination ready to operate. A resume of the total environmental requirements is given below:

Requirements for STALO—Vibration along 3 major axes:

Non-Operational:

(1). 2.5 G at 10 to 36 cps.

(2). 0.036 in. d.a. 36 to 46 cps.

(3). 4 G 46 to 300 cps.

Equipment must operate after exposure to vibration.

Operational:

(1). 0.002 d.a. 10 to 100 cps.

Equipment must operate satisfactorially.

Shock: per MIL-E-5272.

Other environmental & climate

TYPICAL TRAILER MOUNTED EQUIPMENT DISTURBANCES
MUNSON ROAD TEST

	Vertical		Transverse		Longitudinal	
	G	Freq.	G	Freq.	G	Freq.
6" Washboard 5 mph	4.4	300	2.8	250	2.4	350
Belgian Block 20 mph	5.6	300	3.4	300	2.6	300
Radial Bump 15 mph	10.8	250	5.0	400	6.0	300
2" Washboard 5 mph	10.9	300	6.1	300	4.9	375
Spaced Bump 20 mph	21	200	17.8	300	12.4	300

conditions: per MIL-E-5272.

Mobility: Munson Road Test (see Table).

Delicate Equipment — The Hawk equipment operates in the high frequency region associated with radar. Mechanically, the device consists of a rugged rectangular frame made of aluminum sections supporting a cylindrical tuned resonant cavity, servo-control system, and associated electronic elements. Electrically, the system is required to provide an absolute frequency reference.

The electrical output characteristics of the device are so sensitive to external disturbances that a finger snap or normal conversation in the region of the device will result in a deviation beyond allowable limits. The passage of a draft across the tuned cavity will result in an excessive detuning and any high frequency vibration above 0.01 G will result in a malfunction. This is an ultra sensitive device and is typical of a design problem involving overall system performance.

Design Analysis — Because of the complex nature of the system only the details concerning the enclosure and protective isolation are discussed here. The factors involved in the design analysis are listed, and are typical of any

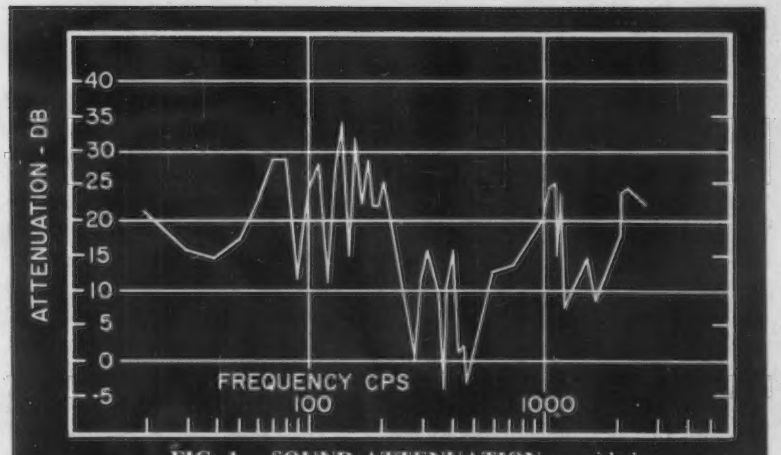


FIG. 1. SOUND ATTENUATION provided by STALO box is generally better than 15 db across the band in critical region.

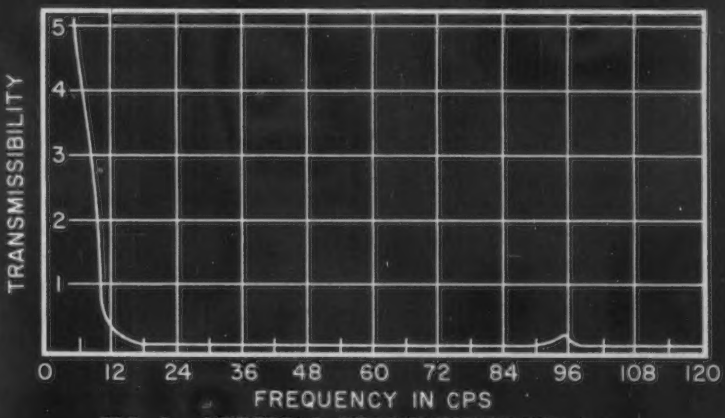


FIG. 2. VERTICAL TRANSMISSIBILITY for operational inputs to STALO enclosure at room temperature. Input = 0.002 in. $\frac{\text{axial}}{\text{vertical}}$, and load = 43 lb axial for enclosure and mockup.

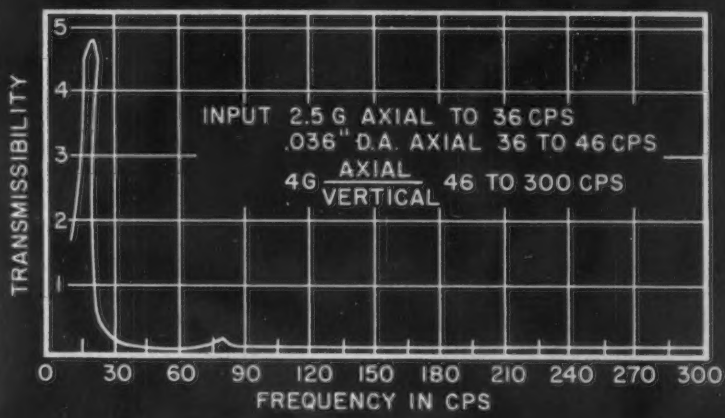


FIG. 3. NON-OPERATIONAL inputs are greater. Curve shows vertical transmissibility envelope. High frequency structural response has been eliminated.

Composite damped structural design cuts 100 lb and $700 from Hawk "black box"

thorough mechanical mounting system design:

(1) Vibration—Operational and Non-operational, (2) Shock, (3) Acoustical Excitation or Noise, (4) Structural Response, (5) Ultimate Strength, (6) Operational and Non-operational Environments, (7) Heat Transfer, (8) Overall System Weight, (9) Equipment Fragility, (10) Maintainability and Equipment Accessibility, (11) Cost.

The Final Design—The design evaluation based upon these factors resulted in a composite mounting system with two stages of isolation. The complete system consists of a double walled controlled response enclosure. It acts as an acoustical shield and incorporates slides and a tray assembly on which the supported equipment is mounted by means of four elastomeric isolators in a center of gravity suspension system.

External isolators are located at the bottom of the acoustical box shield. They are designed primarily to protect the equipment against the operational environment encountered during cross-country vehicular transportation, yet provide a high degree of isolation during the search and launching operations of the Hawk Weapon. The rectangular enclosure incorporates damped structural elements and provides acoustical attenuation of ambient noise and a controlled response structural attachment between the external mountings and the sensitive supported equipment. The internal sliding tray assembly allows easy access to the supported equipment for periodic maintenance and calibration of the equipment. The internal isolators provide the final degree of attenuation in the system and introduce an elastomeric discontinuity between the non-damped sliding tray assembly and the supported equipment.

The damping treatment of the controlled response structure consists of a peripheral arrangement of damped hat sections around the center of the box. Diagonal damped-hat-sections are also used across each of the remaining half panels on all sides of the box, including the front and rear covers. A special elastomeric foam is used to fill all the void spaces in the double walled rectangular box. The effectiveness of this combination treatment was determined by transmission loss and vibration tests. For transmission loss measurements, the box was placed in a reverberant room and excited by a discrete frequency sinusoidal sound. The sound level was measured inside the box with covers on and compared to the sound level outside the box measured on the side of the exciting source. The critical operating frequency range is 0 to 100 cps for noise excitation, although sound attenuation tests were made up to 2,500 cps. The sound attenuation in the critical region is generally better than 15 db across the band. (See Fig. 1)

Amplification of the input sound in this design occurs only at 370 and 460 cps and in both cases magnification is slight and very sharply peaked. The sound transmission properties across the entire frequency band to 2,500 cps are very good. Vibration response characteristics of the complete system were determined by test. Vertical transmissibility characteristics are shown in Fig. 2 for the operational input, and in Fig. 3 for the non-operational requirement.

Frequency response characteristics in the longitudinal and lateral directions were at least equal to the performance in the vertical direction. All high frequency structural response has been eliminated over the entire frequency region even though this is a typical sheet metal structure made mostly from 0.064 in. aluminum alloy riveted and spotwelded. The slight peak just below 100 cps is the vertical resonance of the internal isolators. Field tests during actual operating conditions in which several missiles were fired near the mounted equipment have been performed. No malfunction was noted and the STALO system performed with required accuracy.

Original Design Failed — The original design using classical acoustical shielding and fabricating techniques resulted in a system that weighed 143 lb total and could not meet the field mobility requirements. (It was designed by another company). The redesigned composite damped structure weighed 43 lb total and functioned satisfactorily under both test and actual operating conditions. The emphasis in this design approach was to bring the dynamic working stress level closer to the static working stress level, and make the design more compatible with the total environment.

Methods to control vibration, shock, and noise levels as well as the associated environmental conditions, must be included at the beginning of any program. System design is no longer simply a matter of packaging components but must be a complete analysis involving static and dynamic requirements compatible with the operational conditions to produce highly reliable products.

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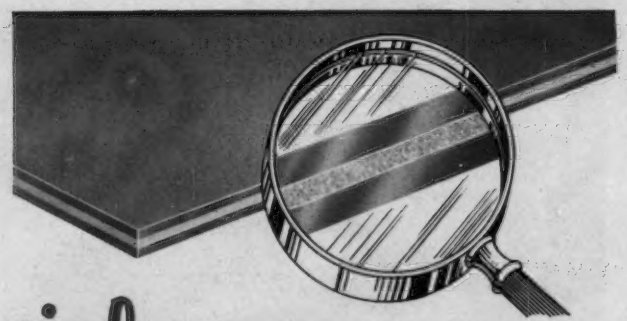

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Space Navigation— The Challenge and The Progress

Optics plus powerful cooperative pulse radar offer promise as Earth-based systems; Optical-geometric methods look good to fill needs of space-ship borne midcourse guidance

OPTICAL METHODS provide most accurate data of all Earth-bound navigational aids. Baker Nunn cameras provide accuracy of 1000 mi at 100,000,000 mi by photographing vehicle against star background. Better cameras are on the way.

Some of the problems of interplanetary navigation have already been solved. Others are a long way from being solved; unfortunately these are the ones that really count. Some of our present equipment is usable. A great deal of new equipment must be designed and built.

Let's take a look at what we have, and what we need.

An interplanetary flight is usually thought of as consisting of three phases:

- Launch phase
- Midcourse phase
- Terminal phase

In general, adequate sensors and equipment already exist for navigating close to the surface of a planet during the launch and terminal phases. It is in the midcourse phase where our navigational needs are greatest. We must get close enough to the destination planet for the terminal equipment to operate. Since an error of 1 ft/sec out of a total velocity of 36,000 ft/sec at launch will cause a miss at Venus of 23,100 mi, or 21,850 mi at Mars, the necessity of midcourse

PHENOMENAL ACCURACY for midcourse guidance data could be provided by 200-in. telescope at Mt. Wilson. Vehicle the size of Echo could be tracked to 30 x 10^6 mi.

guidance is apparent.

The midcourse path will be in the form of a perturbed ellipse having the Sun at one focus and which intersects the orbits of Earth and the destination planet on either end. Range and velocity are, therefore, two very important parameters in determining the position of the vehicle at any time. With a pre-programmed trajectory and periodic measurements of range and velocity, a relatively simple comparison of the two will determine any deviation from the proper course. For each departure from the programmed trajectory, there is a new optimum trajectory, which immediately requires that a computer be part of the guidance system. The computer is also required to determine the magnitude and direction of the impulse needed to reach the new trajectory.

Earth-Based Systems

Beam Riders—Let us look at what can be done with command systems based on Earth. Beam-rider systems may be excluded because even with a directing error of 0.010 deg (the approximate angular accuracy of the FPS-16 tracking radar), assuming the necessary power to be available, the navigation error at 100 x 10^6 mi would be 17,400 mi.

Pulse Radar—The best active radar system we have requires sophisticated correlation methods and months of processing to determine the range of an object 7700 mi in diam at the distance of Venus.

However, if our space vehicle carries a beacon (cooperative radar system), good range information should be obtainable to distances of 100 x 10^6 mi or better. With adequate power, the range accuracy of the radar does not deteriorate with distance. Even so, the directional accuracy cannot be better than that of the beam rider mentioned shows.

Doppler Radar—Doppler radar systems which are being used successfully in aircraft navigation today can, with modification, be employed with space vehicles. They may be used in either active or cooperative arrangements to extract radial velocity measurements. Power considerations would limit the range of an active Doppler radar to the early part of the launching phase, but the cooperative system gives promise of being useful at interplanetary ranges. Fig. 1 gives an indication of power requirements, assuming a 10 decibel signal to noise ratio, 10 cps bandwidth, noise temperature of 300°K and a 5 decibel loss factor.

Optical measurements offer most accurate means of determining the position of a space vehicle

Radio Interferometers — Radio interferometers have been successfully employed both with satellites, and in astronomy as tools for determining the location and size of radio noise sources. The angular resolution of such a system depends primarily upon the separation distance of the antennas measured in units of wavelength. The accuracy obtainable in position location depends directly upon the accuracy with which the difference in phase of the signals at the separated antennas can be measured.

The relation between phase measuring accuracy and angular position is given by the following equation:

$$\delta\theta = \frac{\lambda}{2\pi D \cos\theta}\,\delta\phi$$

$\delta\theta$ = error in angular position
$\delta\phi$ = phase error
λ = wavelength of the signal
D = baseline length

Minitrack, working at 108 megacycles and using a 50 wavelength separation distance, is capable of making angular measurement with an error of the order of 20 sec of arc. This corresponds to an error of 10,000 mi at 100 x 10^6 mi. Range capability is determined by the signal strength, the gain of the antenna, and the noise figure of the receiver. These factors limit the present range of the Minitrack system to about 2000 mi.

With increased power, longer baselines, and improved receiving techniques, the range capabilities of current radio interferometers can be extended to interplanetary distances. The Microlock system is currently being used in most tracking receivers to improve the range capability. Ordinarily, a fixed tuned receiver would have to employ a wide bandpass in order to accommodate frequency variations in the received signal caused by Doppler shift. With Microlock, a voltage controlled oscillator is made to track the received signal by being locked in phase with it. Thus, input bandwidths as narrow as 10 cycles can be used. This sharply reduces the noise level and results in sensitivities as much as 1000 times better than those for non-tracking receivers.

Optical Measurements—Optical measurements provide the most accurate means of determining the position of a space vehicle. Here's why: By photographing a space vehicle against the star background, angular positions can be determined to within 2 sec of arc, corresponding to only about 1000 mi error at 100,000,000 mi. This accuracy is currently being achieved with satellites using the Baker-Nunn cameras. For tracking at the ranges of interplanetary travel, however, much larger apertures and substantially greater reflective power at the space ship will be required.

If our largest telescopes can be made available for photographic tracking of space ships, and assuming that the reflectivity can be increased, it is probable that this technique combined with cooperative pulse radar ranging will determine the trajectory of a space ship with sufficient precision to establish it in its midcourse trajectory. The 200-in. telescope at Mt. Wilson has a visual magnitude limit of 22.5 to 23.0 for a 60 to 80 min exposure. This would make it capable of tracking a 100-ft sphere, like Echo, to a distance of 30 x 10^6 mi.

By celestial mechanics, it is possible to compute the trajectory from three photographic observations alone. However, because of the extreme precision required, pulse radar ranging will undoubtedly be a highly desirable source of additional data, and it may even be desirable to supplement these systems by cooperative Doppler measurements. Space, weight, and power requirements of the equipment to be carried by the space ship will, of course, limit the choice of navigation aids to the absolute minimum required to get the necessary precision.

Vehicle-Based System

Optical—Geometric—By determining the line of sight to the Sun, and at the same time determining the intercept of the projection of this line on the celestial sphere, we establish the position of a line in a heliocentric coordinate system. If we have precise stored data on the orbit of our destination planet, and we observe its apparent position on the celestial sphere, we can determine a second line in our reference frame. By computing the intersection of these two lines, we fix our position. And from a series of these fixes, we can compute our velocity vector.

There is every reason to believe that directional measurements good to 2 sec of arc or better can be made in this way from a space ship, and that mechanized methods for making these measurements can be developed.

As a check on our line crossing, it would be convenient to have another nearby reference object at a high latitude with respect to the plane of the ecliptic. Nature hasn't provided us with such an object. But, there is no obvious reason to believe that as the science of interplanetary transportation progresses, we cannot launch a series of navigation sun-satellites whose orbits will be inclined about 90 deg with respect to the plane of the ecliptic.

Active Pulse Radar—The limited power capability that can be carried in a space ship does not make active pulse radar seem attractive. It would be possible during the early stages of flight to obtain range from the nearest point on Earth's surface and, by a suitable data reduction method, to obtain some directional information on the basis of observations of

discrete features. But as a major midcourse navigation system, active pulse radar appears least useful of several other methods.

Cooperative Pulse Radar—Since the limited power of the space ship radar can now be supplemented by a powerful Earth-based beacon with a high-gain antenna, this system could yield good range data with respect to Earth. Directional accuracy, however, would be limited by the dimensions of the antenna system carried in the space ship, and would only be in space ship coordinates. Until we can establish beacons on other planets, this system will be limited to determination of range and range rate, with respect to Earth.

Active Doppler Radar—Limited power and range, and the fact that it can measure only range rate with respect to the Earth seriously limit the usefulness of the active Doppler radio.

Cooperative Doppler Radar—Again, as in the cooperative pulse system, range limitations can be eased by providing a powerful stable transmitter on the earth, which can be used either in a one-way or round-trip mode of operation. However, this system alone, until we establish the necessary facilities on other planets, gives us only radial rate and integrated range with respect to the Earth.

Passive Doppler Methods—A new and interesting field is opened by passive Doppler methods since we know that electromagnetic waves over the entire radio, infrared, visual, ultraviolet, and gama spectrum ranges are radiated by a wide variety of sources. The spectra of some of these sources are characterized by emission or absorption lines that are reasonably narrow and stable in frequency. Many of these sources are extremely small in angular extent. The possibilities of deriving useful information by Doppler measurements are extremely good.

A few possible applications of natural radiation, both electromagnetic, and particulate, do not at this time appear particularly promising.

Measurement of Sun—To get a measure of distance from the Sun, we could measure its apparent diameter. Photographs made with the Lyot monochromatic photoheliograph at the McMath-Hulbert Observatory of the University of Michigan illustrate some of the difficulties in obtaining a precise measurement of the diameter of the Sun. Position errors inherent in this method can be many thousands of miles in magnitude.

Radiometric Measurements of the Sun — At 93,000,000 mi distance from the Sun, an increase in distance of 100,000 mi will change the total energy received per unit area by only 0.22 per cent. This is not far above the threshold of resolution of our best measuring equipment. The precision needed for interplanetary navigation is far greater.

Cosmic, Gamma and Van Allen Radiation—To get directional information, radiation must be received from a discrete source. To provide usable Doppler information, for determining a component of our velocity vector, the source must have a known velocity with respect to our frame of reference, and must emit discrete line spectra. As far as we know, cosmic rays have a wide range of energies, and come from all parts of the universe. There is not yet any information to indicate that gamma radiation in space meets the criteria given above. The lower Van Allen belt apparently contains trapped particles following helical trajectories of variable radius about lines of force of the Earth's magnetic field. In the upper belt and beyond, particles travelling radially away from the Sun are probably present, but seem to offer less promise than optical methods for navigation. It is difficult to foresee any useful navigational applications for any of these classes of radiation.

Hydrogen 21 cm Line—The degree to which the hydrogen line may be employed in determining the velocity of a space vehicle depends upon the intensity of the line, its sharpness, and the angular extent and location of the sources. Emission lines from the hydrogen clouds in space are generally complex and very broad because of the thermal motions and other turbulence within the clouds and also because of differences in radial velocity of various clouds along the line of sight. When a radio noise source at higher temperature occurs behind a hydrogen cloud, however, the cloud acts as an absorption medium and very narrow lines result. Fig. 2 shows both the absorption and emission profiles of the hydrogen line obtained from the region of the Cassiopeia A source. With the absorption lines it is possible to obtain velocity resolutions of 148 feet per second using a complex radiometer with a 50 foot antenna. The addition of a maser permits resolutions down to 12 ft/sec. This type of equipment, however, is hardly capable of being carried by space vehicles.

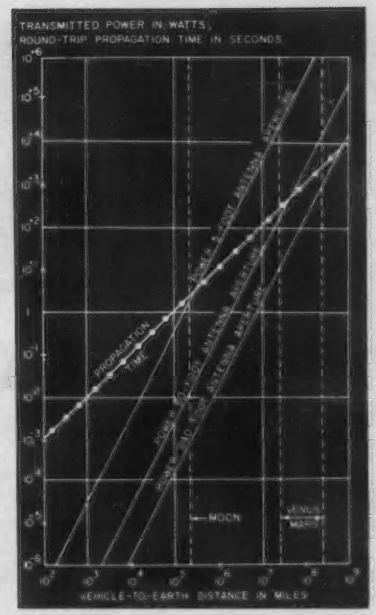

FIG. 1. POWER REQUIREMENTS of Earth-based doppler radars are shown for several antenna apertures. A 10 db signal to noise ratio is assumed, as are 10 cps bandwidth, noise temperature of 300°K and 5 db loss factor. Cooperative Earth-vehicle systems show some potential for space navigation.

Sun is only source which provides adequate energy for high-accuracy spectroscopic measurements

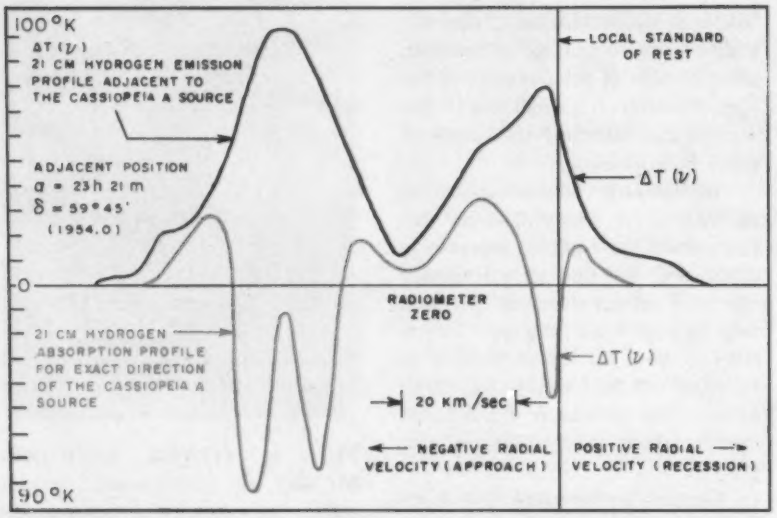

FIG. 2. HYDROGEN 21 CM LINE can be used to measure velocity of spacecraft; but, depends greatly on intensity of line. Shown are profile from direction of Cassiopeia, and comparison profile from 1 deg away.

Doppler Measurements — Sun Source — Radial velocity with respect to the Sun would be a very useful piece of information for navigational purposes. In the solar spectrum, the barium line with a half width of 0.03 Angstroms might be considered. If we can measure its position with a precision of one part of 1000 or to 0.00003 Angstroms, velocity can be determined to better than 2 meters per second. The Babcock magnetograph, as originally designed with two narrow slits, one on each wing of the line, or as modified to use two very narrow birefringent filters, with suitable photoelectric pickoffs and a balancing servo, is capable of precision of this order.

Unfortunately, the Sun is not completely cooperative. Photographs made at the McMath-Hulbert Observatory with a long-focus vacuum spectrograph of unusually rigid construction, show the local variations in radial velocity of the absorbing gases on the surface of the Sun. These local turbulence currents are of the order of 1 to 2 kilometers sec so that lines formed from integrated sunlight are broadened somewhat. A few telluric lines, formed by absorption in the Earth's atmosphere, are very nice and straight, showing that the velocity ripples are not instrumental errors.

The Sun is the only source which provides adequate energy for high accuracy spectroscopic measurements. Radiation received from the brightest stars is approximately only 1×10^{-10} as intense as that from the Sun. There is a scarcity of definite photometric data on steller line profiles.

New Methods—The feasibility of coherent molecular amplification at optical frequencies has recently been demonstrated in the laboratory. This technique could lead to a means for bringing energy in the spectral lines of stars to a level where very precise Doppler measurements could be made. With sufficient energy and extremely narrow lines it should also be possible to use an optical heterodyning technique wherein a spectral line from a stellar source would be beat against another line from a "local oscillator" to provide a difference frequency. This difference frequency could be arranged to be in the radio frequency range where very accurate measurements are possible and where, therefore, Doppler shifts could be measured with great precision. If two lines in the vicinity of 6000 Angstroms were mixed to give a difference frequency of 10 kilomegacycles, for example, a velocity of only 1 meter per second would result in a frequency shift of 1.7 megacycles.

Image intensifiers are currently under development which may make it possible to increase the range of optical telescopes as much as 45 times. Such devices do not preserve the spectral content of the source being viewed, and consequently would not be of value in optical Doppler work. By increasing the range of present day telescopes, however, they will be of great value in optical detection and tracking of space vehicles.

This special report assembled through the cooperation of Dr. D. L. Birx, Franklin Institute Labs, and L. P. Tabor, Missile Surface Radar Div., RCA.

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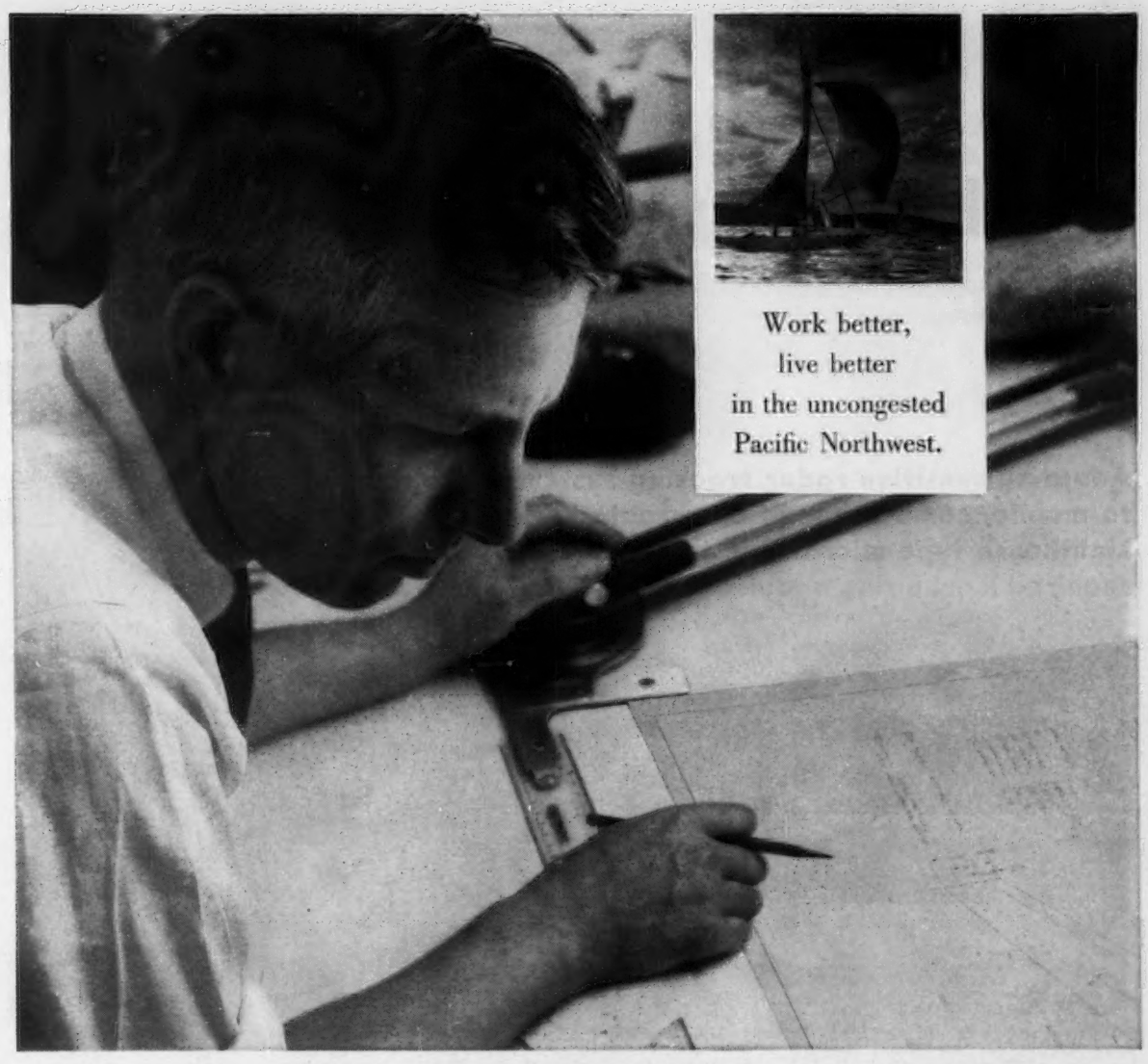

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FIELD OF INTEREST

STALO Sharpens Hawk's "Vision"

Adapting sensitive radar tracking system by Raytheon to mobile, combat conditions created environmental problems; Lighthouse type microwave triode in tunable coaxial cavity required immunizing against acoustical and mechanical vibration

Eugene T. Smith and **Raymond J. Ryan,** Raytheon Co.

An ordinary-looking rectangular box about 23 x 14 x 13 in. helps give Raytheon's Hawk missile eyes like its feathered namesake's.

The box contains an extremely sensitive stable local oscillator system referred to as STALO; for those involved in the design and production of this package it could have been called "Pandora's Box."

Almost three years of effort are represented by this box and its contents. Refinements attained from this extended effort are as follows:

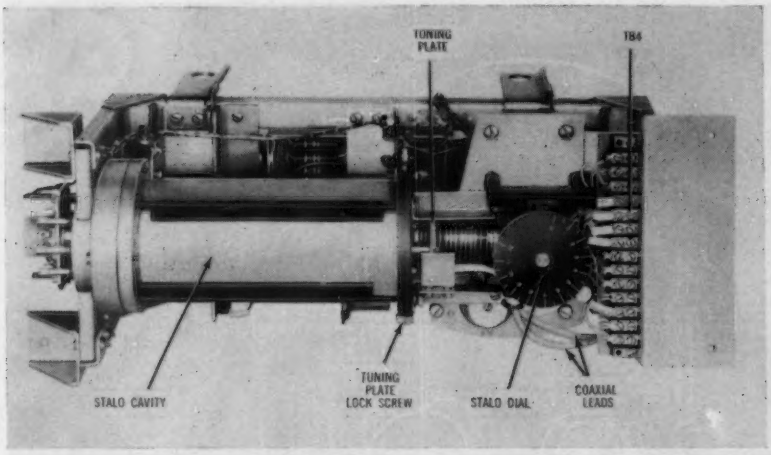
1. Cost reduction from $1300 to $600 per unit.
2. Weight reduction from 143 lb to 47 lb.
3. Appreciable increase in reliability.
4. Ease of replacement.

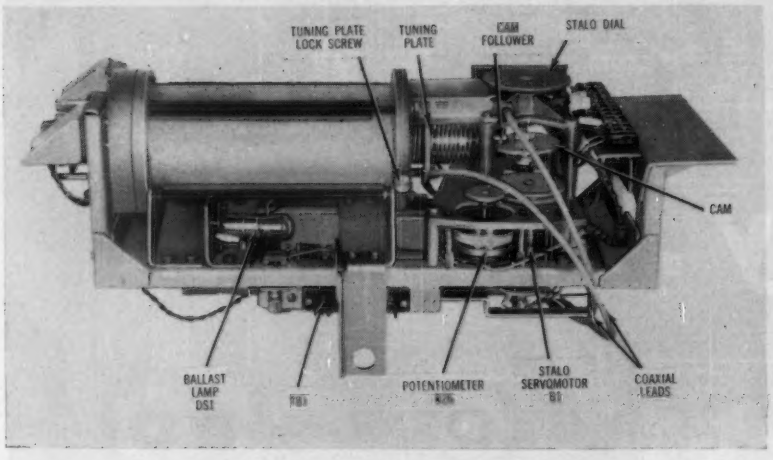
The Hawk hunts its prey both by Pulse Acquisition Radar (PAR) and Continuous Wave Acquisition Radar incorporating a Moving Target Indication (MTI) video system.

To provide MTI, features are added to a pulse radar to detect minute changes in signal return, pulse-to-pulse. The features include: (1) supersonic delay lines, operating at IF frequency; (2) a reference coherent oscillator (COHO); (3) the provision of a very stable local oscillator (STALO).

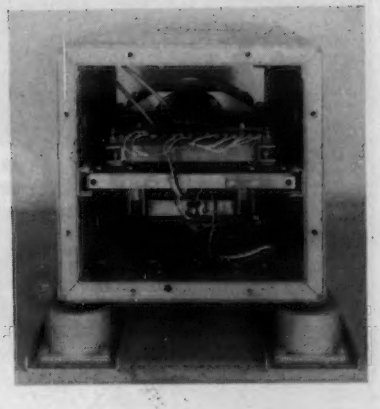
How System Works—The received pulse and local oscillator signal are combined in a heterodyne circuit to produce a pulse of energy at the intermediate frequency. This received pulse has a distinct phase relationship to the local oscillator signal. This phase relationship will vary for a moving target, but be constant for a stationary target. Circuitry which provides an output for the varying phase condition, but none for the fixed phase condition, provides the moving target information. Any incidental frequency modulation imposed on the local oscillator will produce deviations in the pulse-to-pulse phase of the IF signals. This will limit the radar ability to detect moving targets and therefore the local oscillator must be isolated from any disturbances which would result in modulation of the output.

The Hawk STALO consists of a lighthouse type microwave triode mounted in a tunable coaxial cavity system. Spacing between electrodes





STABLE LOCAL OSCILLATOR (STALO) System of Raytheon's Hawk missile is shown at left (top view) and lower left (side view) without its case. End view of system is seen directly below, in rectangular case with end-closures removed. Three-stage suspension system, visible in end view, comprises two stages of vibration mounts within the case, plus external shock and vibration isolators supporting the case.



of this type of tube is about 0.002 to 0.003 in.; the operating frequency is determined by the spacing of the grid to plate electrodes.

Stability Essential — For electrical reasons, these electrodes are mounted rigidly to the cavity assembly. Hence, any vibration from acoustical or mechanical sources incident on the cavities, appears on the tube electrodes and causes corresponding variations in the oscillator output frequency.

For optimum radar MTI performance of the Hawk, the short-term stability of the STALO must be of the order of one part in 10^9. This limits the magnitude of electrode displacement due to vibration to extremely minute quantities.

The design of the STALO cavity originated in radar tracking systems housed in permanent installations where transient disturbances could be easily controlled. Adaptation of this system to mobile combat conditions created a number of environmental problems.

Early tests showed that vibration energy from ambient noise was enough to cause the STALO to exceed the allowable frequency deviation permitted by the radar system requirements. This was in spite of the fact that the STALO was mounted in a vibration isolation system. After a series of experiments with different vibration-mount configurations, a three-stage system was chosen, which gave a high degree of isolation. This system involved two stages of vibration mounts inside the main case, plus an external stage combining shock and vibration isolators. The case and the mounting stem were developed by the Lord Manufacturing Co., Erie, Pa. (For a detailed description of the STALO system environmental container and mounting system refer to page 22.)

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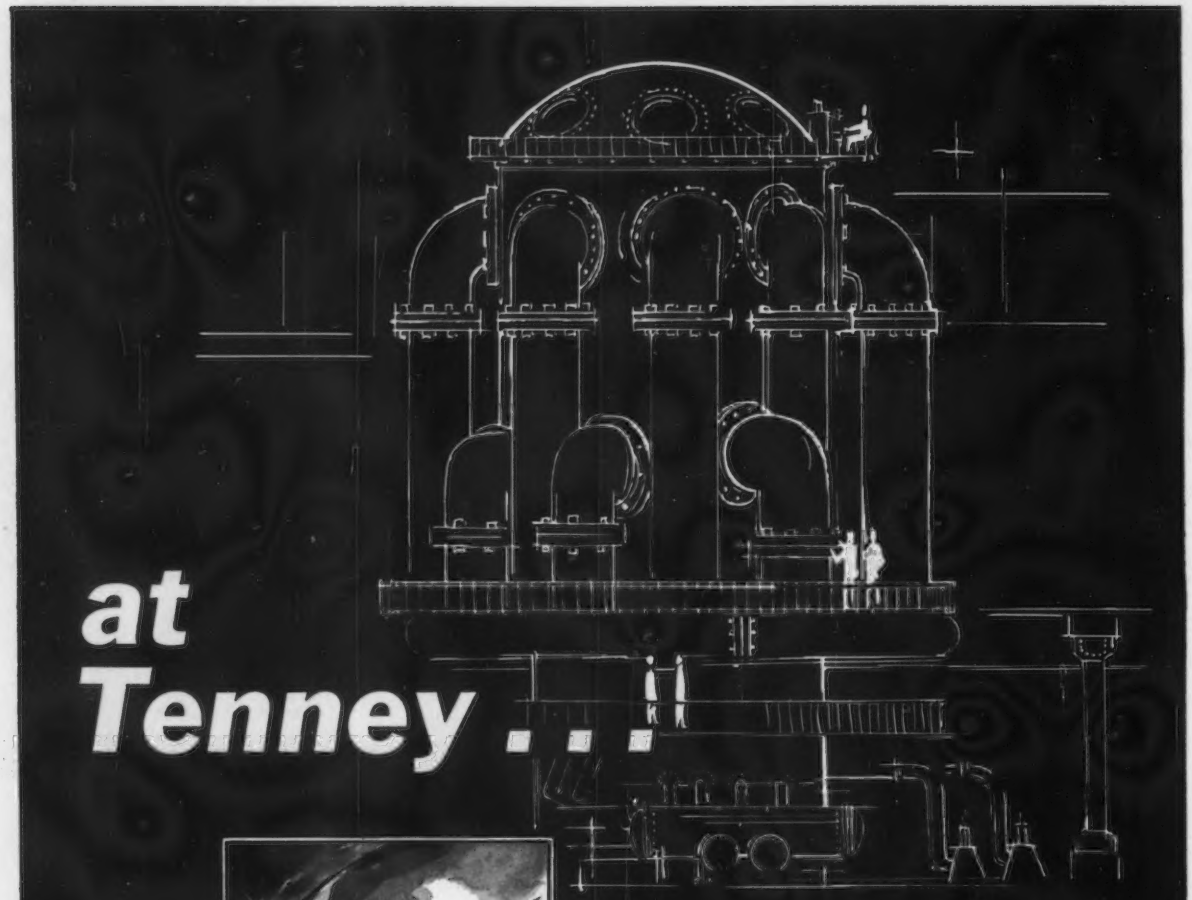

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Magnetic Suspension Holds Wind-Tunnel Models

System developed in France eliminates model support structures; Interference problems in data acquisition greatly reduced; World interest stimulated by initial success with 12-in. tunnel

By Ronald A. Cole

Collection of data from wind-tunnel models has always been a difficult process. In addition to the various tunnel effects which have to be allowed for, the model supports themselves introduce further deviations from the free-flight condition. Support interference can seriously modify airflow in the working section, while support rigidity and vibrational modes can distort the true force values.

The French National Aeronautical Research body known by the initials ONERA, has developed the suspension of models by a magnetic field. Measurement of the current needed to maintain the model in equilibrium would give a measure of the forces developed. Advantages of such a system are obvious, and it is of interest that this method has been tried with models up to tunnel speeds of Mach 1. Results of the initial work have been encouraging.

Light-Beam Control — Intrinsically, the method of magnetic suspension and force measurement is an automatic process; the system is based on proven principles and equipment.

A body acted upon by gravity may be suspended in space by a constant magnetic force for only a short time. The equilibrium of such an arrangement is purely instantaneous, and if it is to be maintained continuously it requires controlling or "centering" the current to the magnet, relative to the position of the body in space. In the method developed by ONERA this is done by using a parallel light beam falling on a photoelectric cell. In the equilibrium position the body is positioned to eclipse a portion of the beam so that any movement allows more or less light to fall on the cell.

This cell is coupled to a resistance in the grid circuit of an amplifier-triode, the anode current of which activates the electromagnet coils. In the equilibrium state the quantity of light falling on the cell is such that the grid potential corresponds to a current in the anode circuit. This being just sufficient to produce a magnetic field which will support the weight of the body.

A horseshoe electromagnet is positioned above the tunnel working section, with its poles lined up with the axis of the tunnel. Lines of magnetic force are channelled by a bar of soft iron imbedded in the body of the model to be tested. When in the equilibrium position, the lower extremities of the model lie half way across two beams of light which are spaced a short distance apart along the tunnel. Each ray of light falls on a corresponding photoelectric cell. Lift experienced by the model gives the effect of lessened weight with a consequent rise towards the magnet.

This movement is detected by the photoelectric cells, and the cells immediately reduce the current to each pole of the magnet, to keep the model in its original position. The total reduction of current is a measure of the total lift, while the difference in the reduction of current to the two poles is a measure

Parallel light beams with 0.4 diam used in ONERA's 12-in. wind tunnel

of the pitching moment.

Ring Magnet — Forces tending to displace the model along the tunnel axis, which should be truly horizontal to obviate gravity components from affecting the drag readings, are balanced by another magnet. This takes the form of a ring, and is placed around the outside of the circular-section tunnel. A third light beam is used to establish the equilibrium position and measure the drag force.

Another horseshoe magnet used is arranged to have its poles horizontal; this one, mounted on the side of the tunnel, controls the model in yaw and side slip. Here again, two light beams are used similar to those of the lift and pitch magnet. Any tendency for the model to roll is controlled by a flat plate of soft iron fitted in the vertical surface of the model. This will tend to remain vertical under the influence of the lift controlling magnetic fields.

A system of this type has been tested in a tunnel of about 12 in. diam. The parallel light beams used in this case are about 0.4 in. in diam. The photocells used were chosen for their insensitivity to magnetic fields. Each cell feeds a germanium preamplifier, and this is essentially the datum control device. The preamplifier is in turn followed by a Thyratron power amplifier the output of which activates the coils of the electromagnets. To reduce eddy loss, electromagnet cores are of the usual soft iron laminates.

Circular magnet consists of 1800 turns of wire; two Thyratrons provide a current output of 12.8 amps rectified at 400 v. For the lateral system, four Thyratrons are used per coil. These are mounted in monophase rectifying pairs so that the current rectified by one pair reduces as that rectified by the other pair increases. Winding of the coils is such that the magnetic field in the iron cores is nil when the currents in the coils are equal—a condition corresponding to the equilibrium state of the model.

When a model is placed in the tunnel, in a position of equilibrium, calibration of the suspension and measuring system is carried out using pulleys and weights.

The results of a limited number of tests, mainly with the drag values of a body of revolution, have been considered very satisfactory and worthy of further development. These were carried out in two tunnels and covered the speed range up to Mach 1.15.

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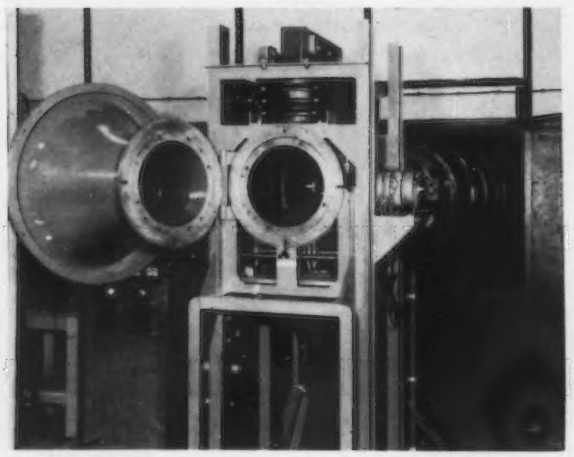
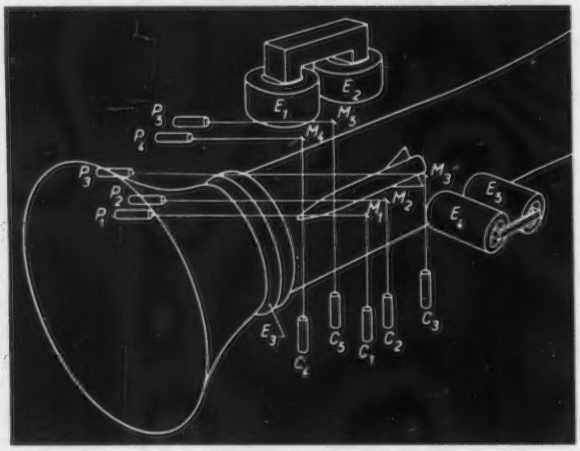


MISSILE MODEL can be seen suspended by magnetic forces in the working section of wind tunnel. The large horseshoe magnet, for controlling lift, can be seen on top of tunnel; yaw and sideslip magnet is mounted on right side of tunnel.



MAGNETIC SUSPENSION wind tunnel developed by ONERA is shown schematically. Items marked "E" are the electromagnets; those marked "C" are photoelectric cells; "P" denotes the light sources; and "M" marks the mirrors.

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Evaluating Fine Magnet-Wire For High-Temperature Service

Environmental test used by General Electric predicts insulation behavior realistically

By H. R. Broadley and R. S. Norman
General Electric Co., Instrument Dept., West Lynn, Mass.

In aircraft and missile applications there is a wide use for 3 and 7-mil diam ceramic-coated magnet-wire for high temperature duty. Specific applications include position transmitter synchros, pressure transducers and other airborne synchros and relays. Majority of earlier work on ceramic-coated magnet-wires has been in sizes larger than 10 mils. Therefore, only limited data on the winding characteristics and high-temperature dielectric strength of smaller diameter wire has been made available.

This article presents an exploratory evaluation of small-diameter, high-temperature magnet wires Complete test results on three commercially available wires are presented and a simple low-cost testing technique is described.

As ceramic coatings are thin and not as flexible or abrasion-resistant as organic insulation, the severest application is in stator coils. Because of design limitations, the wire wound on the stator coil form of the position synchro, involved in this case, had to conform to 90 deg bends of small radius in passing over stator lamination edges. Turn-to-turn breakdowns could, therefore, cause the most difficulty. Such breakdowns result primarily from cracks and breaks in wire insulation as it passed over the stator edges.

Testing Method—A fast, economical mandrel test was devised to simulate the edges that the fine magnet wire would meet under actual winding conditions. A stain-

TEST MANDREL, used for evaluation of fine high-temperature magnet wire, is made of stainless steel.

Summary of High-Temperature Magnet-Wire Voltage Breakdown Tests

Wire	Diam in mils (Average 6pread)	Room Temperature Voltage Breakdown: Turn-to-Ground (5 Samples)	Room Temperature Voltage Breakdown: Turn-to-Turn (3 Samples)	550°C Voltage Breakdown: Turn-to-Ground (3 Samples)	550°C Voltage Breakdown: Turn-to-Turn (3 Samples)
A	3 mil	302 285–315	416 415–420	70 (2 samples) 56–84	261 245–300
A	7 mil	306 290–315	393 385–405	270 250–290	348 300–390
B	3 mil	145 97–205	247 240–255	9.0 2.0–20	53 47–56
B	7 mil	221 215–227	288 285–290		148 48–250
C	7 mil	190 134–230	320 310–330	0*	

* Insulation cracked and crazed. Tests were stopped.

less steel arbor with a 0.0105-in. edge radius was used in the evaluations. Several coils were wound and tested simultaneously on the mandrel. For turn-to-ground tests, a ground insulation of two mil woven glass tape was used.

Test coils were hand wound and an even tension of about ½ to ¾ lb was maintained during winding. The mandrel wound with test coils was placed on a fire brick within an electric furnace; leads passed through the sight hole in furnace door. A hi-pot kit, consisting of a Powerstat and two step-up transformers, provided a total of 630 volts a. c. Breakdown voltage was read on a vacuum tube voltmeter connected across the sample coil; breakdown indication was noted on a voltohm meter.

Compositions of wires tested were as follows:

"Wire A"—Copper wire with 10 per cent by weight of nickel plating to protect the copper from oxidation and crystal growth at 500°C; 0.75-mil layer of a partially-cured ceramic insulation required a post winding cure of 1050-1100°F for 45 min. The wire as received appeared gray and quite flexible: no apparent harm was done to the rather soft insulation by winding. After curing, the insulation became hard and brittle, and cracked and flaked off when flexed.

"Wire B"—Copper wire with 27 per cent by weight of nickel cladding. The insulation fully cured as received, consisted of a 0.35-mil, hard, completely cured ceramic having good flexibility and abrasion resistance.

"Wire C"—Nickel plated copper wire insulated with aluminum oxide formed by electro-depositing aluminum on the wire and completely anodizing to form a 0.15-mil coating. Prior to aging, the wire and coating were flexible and abrasion resistant.

The adjacent table summarizes the results of the voltage breakdown tests on the samples.

All wire samples appeared satisfactory on room temperature breakdown tests, although "Wire A" had the highest and most consistent breakdown values at both room temperature and at elevated temperatures. In each sample tested, there was no visible cracking or crazing of insulation when wires were wound over the 90 deg corner on mandrel; however, in all samples majority of breakdowns of turn-to-ground occured at the 90 deg corner.

"Wire C" did not withstand the 550°C test, but the aluminum oxide insulation was not determined to be the primary reason for rejection. The copper conductor appeared "crystallized" as well as oxidized severely in the 550°C air atmosphere. It lost all tensile strength and crumbled at the touch.

In all cases, the smaller the wire diameter, the lower was the resistance to breakdown at elevated temperatures. This is probably due in part to the thinner coatings on the finer wires and the increasing difficulty of providing a constant insulation thickness.

From these tests it was concluded that fine magnet wire will retain over 115 volts turn-to-turn after extended periods of time at 550°C. Although encapsulation studies were not in the scope of the evaluation it is recognized that some form of ceramic coating or glaze will be necessary to support and rigidly fix in place the fragile magnet wires for protection from vibration, shock and humidity.

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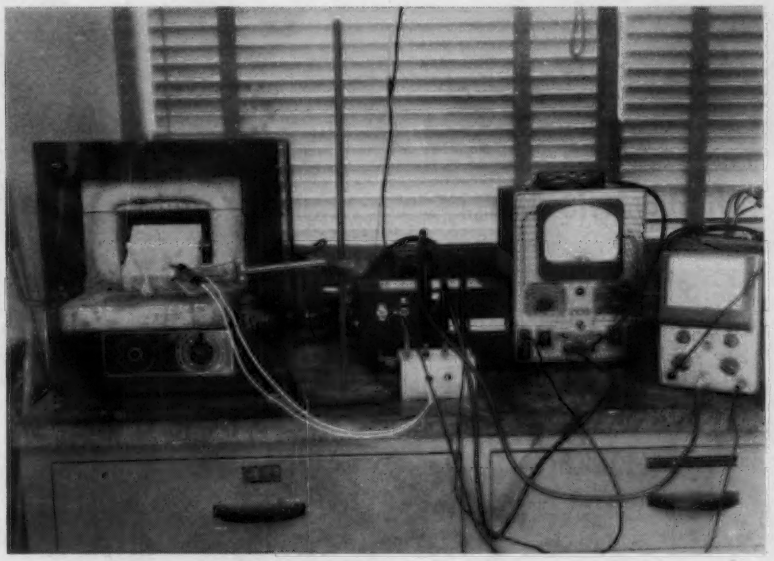
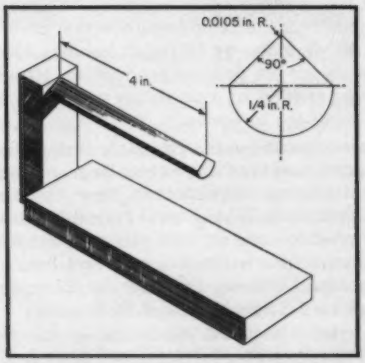


TESTING ARRAY for high temperature wire is shown as used at General Electric's Instrument Dept., West Lynn, Mass.



STATOR COIL for position synchro requires numerous 90-deg wire turns over sharp lamination edges.

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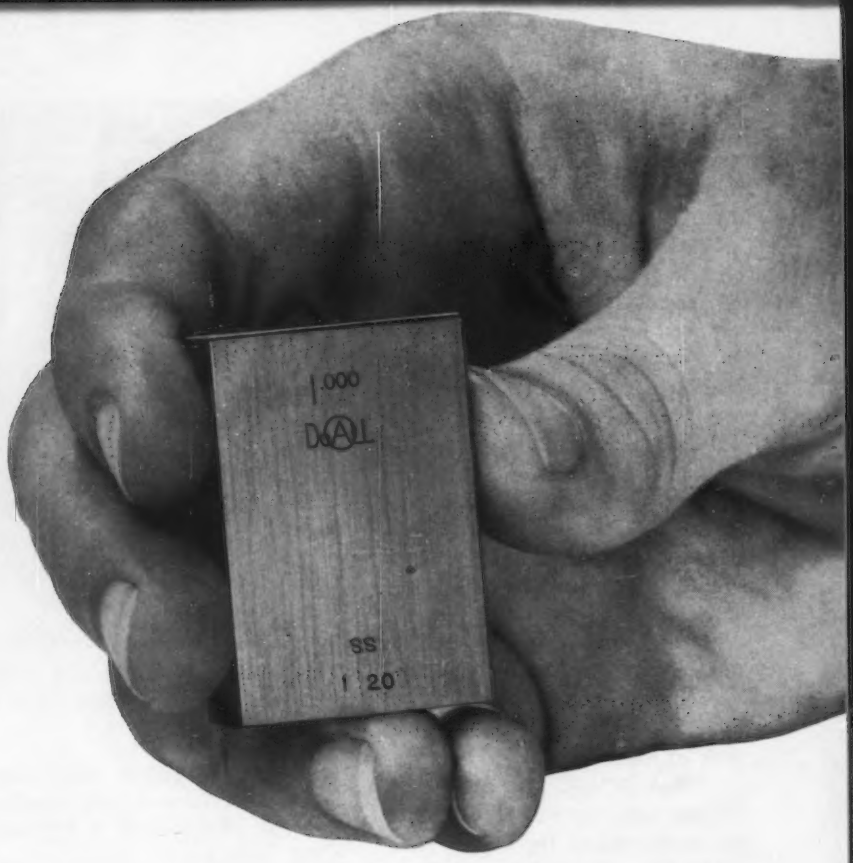
DoALL tells how Lindberg equipment helps produce stainless steel gage blocks



For the DoALL Company, Des Plaines, Illinois, heat treatment of their Stainless Steel Gage Blocks was a most formidable problem. For lasting accuracy these blocks require extremely hard, wear-resistant surfaces, free from growth or shrinkage, as provided by nitrided stainless steel. Case depth must be controlled accurately and the core maintained at full toughness free of stresses. DoALL found the answer to this problem with a Lindberg Gas Fired Vertical Cyclone Tempering Furnace with a Nitriding Retort.

Norman Silver, Chief Metallurgist, and Lindberg Vertical Tempering Furnace at DoALL Company.

NORMAN SILVER, Chief Metallurgist says, "Our Lindberg equipment supplies the uniformity of heat distribution and the fast accurate control that is needed for the exacting requirements of our product. The furnace responds to control almost instantaneously and maintains the temperature within plus or minus 5°. Its 38" diameter by 36" depth handles 200 to 300 pound loads for the desired production. Results obtained have satisfied us completely with this, the latest of our Lindberg furnaces".

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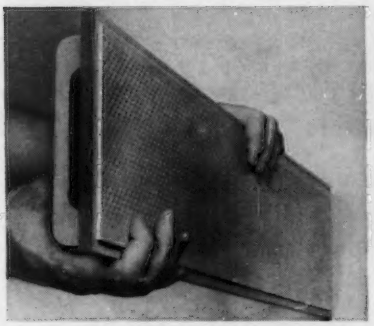
Important facts to know about Laminated Plastics

LAMINATED PLASTICS *What they are, where they can be used*

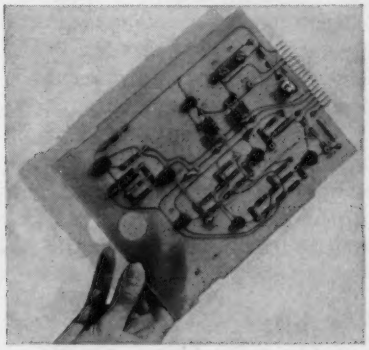
Taylor laminated plastics, also known as reinforced plastics, are thermosetting-type materials formed by impregnating paper, cotton cloth, asbestos, glass cloth, nylon or other base materials with synthetic resins and fusing them into sheets, rods, tubes and special shapes under heat and pressure. These materials exhibit a valuable combination of characteristics, including high electrical insulation resistance, structural strength, strength-to-weight ratio, and resistance to chemical reaction; also adaptability to fabricating operations.

Types of laminated plastics made by Taylor
There are four basic types of Taylor laminated plastics commonly specified and used throughout industry today. They are as follows:

Phenolic Laminates. Paper, cotton fabric or mat, asbestos, glass cloth or nylon bases impregnated with phenol formaldehyde resins. These provide strength and rigidity, dimensional stability, resistance to heat, chemical resistance, and good dielectric characteristics. Some Taylor grades are excellent basic materials for gears, cams, pinions, bearings and other mechanical applications. Others are widely used in terminal boards, switchgear, circuit breakers, switches, electrical appliances and motors. Also in radios, television equipment and other electronic devices; and in missiles as nose cones, exhaust nozzles, and combustion chamber liners.

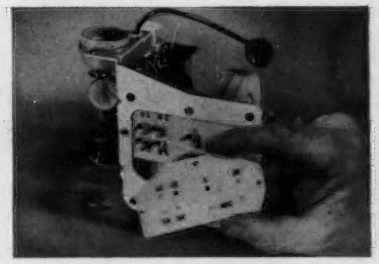


Melamine Laminates. Glass cloth or cotton fabric impregnated with melamine formaldehyde resin. Taylor melamine laminates have superior mechanical strength and are especially desirable for their arc-resistant qualities. Good flame and heat resistance, good resistance to the corrosive effects of alkalis and most other common solvents, besides other favorable characteristics. Typical applications include arc barriers, switchboard panels, and circuit-breaker parts in electrical installations.



Silicone Laminates. Continuous-filament woven glass fabric impregnated with a silicone resin. These laminates combine high heat resistance (up to 500°F. continuous) with excellent electrical and mechanical properties. They are primarily used in high-temperature electrical applications and high-frequency radio equipment.

Epoxy Laminates. Continuous-filament woven glass fabric or paper impregnated with epoxy resin. Glass-fabric grades are designed for use in applications requiring high humidity-resistance, good chemical resistance,



and strength retention at elevated temperatures. Paper grades are used under high-humidity conditions where resistance to acids and alkalis is required. Both grades are characterized by good dielectric strength, low dielectric losses, and high insulation resistance even following severe humidity conditions.

• • •

Recent technical advances in the bonding of various metallic and nonmetallic materials to laminated plastics have opened up new design opportunities. It is now possible to bond virtually any compatible material with a laminated plastic to form a composite which combines the advantages of both. One of the first composite materials was a copper-clad laminate used for printed circuits. More recent composite laminates, usually manufactured to customer specification, include the following: Taylorite® vulcanized fibre-clad, rubber-clad, asbestos-clad, aluminum-clad, beryllium-copper-clad, stainless-steel-clad, magnesium-clad, and silver- and gold-clad. Any one of these materials can be sandwiched between sheets of laminates, too, and can be molded to fit specific requirements.

Send for complete information about any or all of these Taylor laminates. And remember Taylor's new selection guide will simplify your problems in choosing the right laminate for your specific application. Taylor Fibre Co., Norristown 50, Pa.

Taylor
LAMINATED PLASTICS VULCANIZED FIBRE

IN THE ROCKET NOZZLE ENVIRONMENT—

Pick The Right Plastic

Tips on how to: (1) Analyze the design, (2) Specify the parts, (3) Get the quality

By Wesley C. Mace, Chief Plastics Engineer
Edler Industries, Inc.

Design problems in high temperature thermal insulation are divided into two categories. The first deals with insulation subjected to temperature alone, the second deals with insulation subjected to erosion as well as high temperatures. Erosion is usually the result of high velocity gases from the combustion of a propellant.

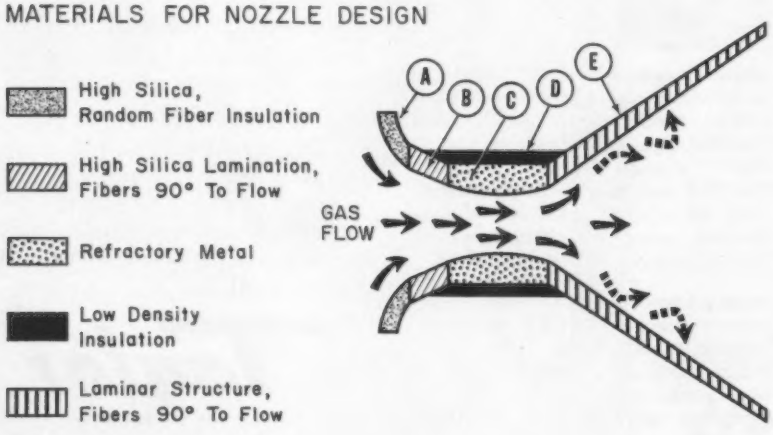
Unfortunately the properties of erosion resistance and maximum temperature drop across a given thickness of insulation are frequently in conflict. Practically all designs are a compromise between the two.

The most commonly used materials have been reinforced phenolic resin compounds. The reinforcements most successful to these applications have been high silica content fibers, including quartz, asbestos, graphite cloth, and nylon. In general, asbestos is used in the 2000 to 3000°F range, with nylon and nylon-quartz or silica combinations in the 5500°F and up range.

Design Analysis—Selection of a material for a particular application involves the analysis of a large number of design criteria. These include temperature, duration of exposure, pressure, direction of gas flow, temperature drop required, and chemical composition of gases.

In many cases, satisfaction of these criteria in a given nozzle assembly will result in a composite structure. A typical one is illustrated. The design is analyzed to show the reason for selection of the various materials.

MATERIALS FOR NOZZLE DESIGN



In the area protected by the part labeled (A), a high temperature, high pressure, and a high velocity combustion gas are the assumed environment. Gases are flowing in constantly changing directions. In this instance a laminar structure would tend to peel. Therefore, a high silica random fiber molded insulation would be recommended.

In the area protected by the part (B) the configuration is that of an entrance (cone). Maximum erosion resistance compatible with the insulation necessary is required. Here a laminated, high silica content structure is recommended with the laminar layers oriented 90 deg to the direction of gas flow. Fibers so oriented have proven to be more resistant to erosion than any other configuration.

In the nozzle throat itself, graphite or one of the refractory metals perform more satisfactorily than any of the insulation materials discussed here. The throat insert (C) is then assumed to be one of these metals. However, since graphite and the exotic metals are high heat conductors, insulation from supporting structure must be supplied at (D).

In the part (D), the only con-

sideration is that of temperature drop since no portion of this part is exposed to erosion. Several types of materials may be suitable. High silica content molding compounds, molded or machined around the insert, wrapped silica tape molded around the insert at a low density, or asbestos tape may all be suitable depending on the degree of insulation required and the ease of fabrication desired.

On the exit cone (E) either laminar structure at an angle 90 deg to direction of gas flow or a randomor milled fibre molding compound may be required. The determining factor in this case is the consistency of the gas stream direction. If turbulence is present to any large degree a random fiber molding may be imperative. In some cases erosion is greater on a random fiber surface than on oriented fiber surface. This may be compensated for by the relative constant rate of erosion in all areas since at any given impingement angle some of the fibers are at 90 deg to the direction of gas flow.

Mechanics of Erosion — The mechanics of erosion at high temperatures on these materials are based on some unique properties. Phenol based resins, when exposed to high temperature gas flow, do not flame, they char. In charring they protect the surface directly beneath. The reinforcement fibers tend to hold this charred surface and retard the erosion from high velocity gases. In addition to the mechanical and thermal resistance provided in this manner, there is an additional benefit derived from the absorption of heat energy necessary to char the phenolic and sublime the reinforcement fibers. The actual cooling effect obtained in this manner is almost impossible to calculate or measure.

How to Specify—In specifying required properties of component parts there have been several approaches tried to insure the achievement of design objectives. They have generally taken the form of either end property requirements or specific processing instructions. For a variety of reasons neither method has been totally satisfactory.

Specifying end part requirements has thus far been concentrated on specifying density. What has not been considered, however, is that, within a given range, density is relatively unimportant. A typical example is in the silica fiber reinforced phenolic parts. Densities have been specified in roughly 3 ranges, i.e., a 80 to 90 lb/ft^3 range, a 100 lb/ft^3 minimum, and a 110 lb/ft^3 minimum.

The 80 to 90 lb/ft^3 density is generally achieved using extremely low molding pressures such as a vacuum bag molding. Its chief use is for strictly thermal insulation applications, however, in erosion areas where the erosion can be allowed to occur at uneven rates, it can be used.

The 100 lb/ft^3 minimum density is the most popular call-out used. Why 100 lb/ft^3 was chosen as the magic figure is unknown; 95 lb or 98 lb may perform just as well. In practice, most moldings will occur at slightly greater densities, the average running around 103 to 106 lb. The 100 lb/ft^3 minimum has caused some designers to presuppose a press molder or autoclave molded part. This is generally true, but in certain cases it is possible to achieve this density with little or no pressure during molding.

Densities of 110 lb/ft^3 in a high silica material or greater, are not practical to achieve in an economic manner. Nor is there any reason to assume that they are particularly desirable from a design standpoint.

Quality Control—Just as important, and in most cases more important than the actual density, is the integrity of the molding. Unfortunately this is a difficult quality to determine. X-rays are not yet universally accepted because of the interpretation difficulties. Ultrasonic inspection shows promise, but a great deal of development work remains to be done.

Specific processing requirements, as a method of insuring quality of parts, probably create more problems than they solve. Most processing requirements are specified from experience on related parts manufactured by a particular type of equipment. Variations in equipment, variations in raw material and intrinsic molding problems presented by an individual configuration almost always require some variation in processing by the molder.

Why Post-Cure? — The final consideration for discussion is post-cure conditions. At the present time there is an overwhelming number of post-cure schedules used for all types of design. Post-curing was an almost automatic procedure for designs of high-temperature phenolics for years. But, the high temperature conditions of those days referred to temperature exposure of several hours at 400°F to 600°F and high temperature resistance referred to retention of physical strength properties at temperature.

Present reinforcements in the thermal insulation and erosion field have virtually no structural strength and are not used in structural applications. Therefore, evaluation of post-cure should be made on the basis of effect on erosion resistance and insulation properties. No conclusive evidence exists that post-cure is beneficial to these parts on a properly cured part and there is considerable evidence that post-cures at temperatures in excess of 300°F for prolonged periods is detrimental to the parts. Prolonged post-cures cause porosity, increase machining difficulties and remove a certain percentage of actual resin solids, especially on the surface. The porosity can act as a focal point for erosion, and the removal of resin solids may adversely affect the char rate.

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Over 15,000,000 ft. of Superior stainless hydraulic tubing helps today's aircraft and missiles to operate efficiently

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How to Test Accelerometers at Low Frequencies

Mechanically simple double-centrifuge system fills gap in frequency spectrum from 0 to 10 cps; Provides source of low-frequency, high-amplitude oscillations

By Rick Ratcliffe, Project Engineer, Rototest Laboratories, Inc.

Until recently, absence of adequate equipment has severely limited the testing of accelerometers at G levels in excess of ±1G, below 10 cps.

This limitation posed no problems in cases where strain gages, crystals or other high-frequency accelerometers were being applied; the d.c. to 10 cps region is a small and generally negligible portion of the spectrum. However, the situation changes where an accelerometer is part of a servo system as in inertial guidance or autopilot controls, and system response is below 20 cps. Then, it becomes necessary to determine the fundamental parameters of the accelerometer, e.g. natural frequency and damping ration, as well as any deviations from the theoretical performance.

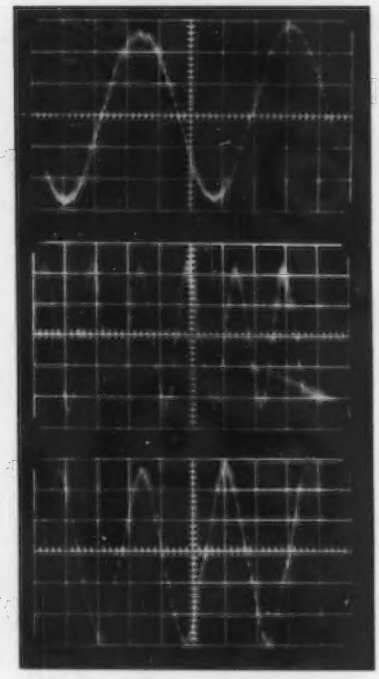
Electromagnetic shaker systems —whether electronically driven or generator driven—are limited basically to frequencies above 5 cps. This is due to magnetic circuit problems and the fact that both electromagnetic drivers and hydraulic shakers possess excursion limitations at low frequencies. Mechanical shakers, slider-crank and scotch-yoke mechanisms lack flexibility as they are either variable-frequency-constant-displacement or variable-displacement - constant - frequency types. A consideration of the orders of magnitude might be more illustrative at this point. At 1 cps, a 10-in. double amplitude of oscillation is 0.5 G; at 5 cps the same amplitude of oscillation is 12.5 G, while at 0.2 cps a 10-in. double amplitude represents only 0.02 G.

Use of any of the devices mentioned above, as a source of low frequency high acceleration levels, would require increasing shaker and power sources to impractical sizes in the case of electromagnetic devices; it would likewise require a monstrous complex of gearing and variable couplings for mechanical shakers.

An actual theoretical solution to the problem of generating low frequency high amplitude oscillations has existed since 1877 (Wischnigradski + and —1G oscillations) and since 1939 (Woolard double-centrifuge). Basically both methods consist of rotating the device under test in a steady G field. The first method utilizes the uniform 1G field of the Earth which for all practical purposes is space invari-

Double centrifuge gives excellent waveforms in low frequency zone of 0 to 10 cycles/sec

ant in the laboratory. The second method utilizes the radial force field produced by a primary centrifuge. This method, used at Rototest Laboratories, poses one complication in the testing of accelerometers that does not exist in the first method, viz.: while the field established by the primary centrifuge is invariant in magnitude at a given radius, there is a distinct gradient of acceleration such that if appreciable movement of the device under test occurs, compensation must be made for the instantaneous changes in radius and consequently in acceleration levels.



ACCELEROMETER RESPONSE is shown to excitation by double centrifuge. Instrument tested in this case is accelerometer (No. 24128M) made by Giannini Controls Corp.; it has an undamped natural frequency of 4.5 cps and damping ratio of 0.5. Each oscillograph record shows response at different frequencies, at ½ G peak excitation. Time base for first picture is 200 MS/cm (each major horizontal division represents 1 cm).

For a simple series analogue type accelerometer consisting of a spring, damper and seismic mass, the response can be predicted from the equation:

$$\ddot{x} + \frac{F}{M}\dot{x} + \frac{S}{M}x = K \cos \omega_2 T$$

The same unit tested on a double centrifuge would respond in accordance with the equation:

$$\ddot{x} + \frac{F}{M}\dot{x} + \left(\frac{S}{M} - \omega P^2\right)x = K \cos \omega_2 T$$

where

- x = seismic mass displacement from equilibrium
- $\dot{x}$ = seismic mass velocity
- $\ddot{x}$ = seismic mass acceleration
- M = seismic mass
- S = spring stiffness constant
- F = Viscous damping coefficient
- ω_1 = angular rate (radians/sec) of primary centrifuge
- ω_2 = relative angular rate of second centrifuge
- ωP_i = $\omega_1 + \omega_2$ the "absolute" angular rate of the seismic mass' line of action or degree of freedom
- $R\phi$ = Radial separation of the primary centrifuge axis and the secondary centrifuge axis (assuming accelerometer mounted with equilibrium point coincident with rotational center of second centrifuge.)
- K = acceleration amplitude = $\omega_1^2 R\phi$

S/M, the square of the undamped natural frequency is effectively lowered by the amount $(\omega_2 + \omega_1)^2$ which is not a constant but varies with the oscillating frequency ω_2. Both phase angle and amplitude response are altered by the double centrifuge method from that which would be obtained through a linear shake. Both ω_1 and ω_2 are known quantities or at least directly measurable. Two measurements at controlled frequencies would suffice to determine the S/M and F/M ratios for a well-made accelerometer.

A comparison of amplitude responce as determined by the double centrifuge method as opposed to a linear shake, yields the following information:

(1) For points less than and remote from the undamped natural frequency, the two response curves are identical.

(2) For $\omega_1 = -\omega_2$, the curves are identical over the entire response range.

(3) For ω_1 greater than zero, with ω_2 less than zero, or vice versa, and $(\omega_1 + \omega_2)$ less than the natural frequency, the curves tend to be identical.

(4) The fundamental parameters of an elementary seismic mass accelerometer (i.e. natural frequency and damping factor) may be determined directly from the response curve obtained with a double centrifuge.

(5) The actual ratio of linear response to rotational response is rather formidable in appearance and is given by the expression: $\times$ linear $/\times$ rotational $=$

$$\sqrt{\frac{1 + (\omega_1 + \omega_2)^2 \left(3\,\omega_2^2 + \omega_1^2 + 2\,\omega_1\,\omega_2 - {}^{r}2\,S/M\right)}{(S/M - \omega_2^2)^2 + F^2/M^2\,\omega_2^2}}$$

Despite the seeming complexity of the algebraic expression for ratio correction factor, numerically it is very close to unity; for a given range of natural frequencies and test frequencies, the maximum error can be predetermined and, if necessary, compensated for in the data.

For example, given an accelerometer with a natural frequency of 20 cps, ± 6G's full scale, primary centrifuge rotation 120 rpm, second centrifuge rotation 0 to 5 cps, the

ratio of linear response to the rotation response-ignoring the damping

$\left(\frac{F^2}{iM^2}\omega_2^2\right)$ and with ω_1 opposing ω_2 is $\times$ linear $/\times$ rotational =

$$\frac{\sqrt{1 + (-3)^2 (75 + 4 - 20 - 800)}}{(375)^2 +} =$$

$$\frac{\sqrt{1 + 9 (-741)}}{(375)^2 +}$$

which is approximately

$$\sqrt{1 + (-0.05)} = 0.975$$

Thus at the highest value of $\omega_1 + \omega_2$), i.e. 2—5 = —3, the maximum difference between theoretical rotational response and theoretical linear response is only 2.5 per cent.

From the foregoing, it is apparent that the double centrifuge can successfully fill the gap in the frequency spectrum, 0 to 10 cps, for the testing of low frequency accelerometers. There is an obvious mathematical complication (correction factors) in testing units with natural frequencies below 10 cps, but this difficulty is offset by the relative ease with which high G levels may be secured and the excellent wave form which is obtainable.

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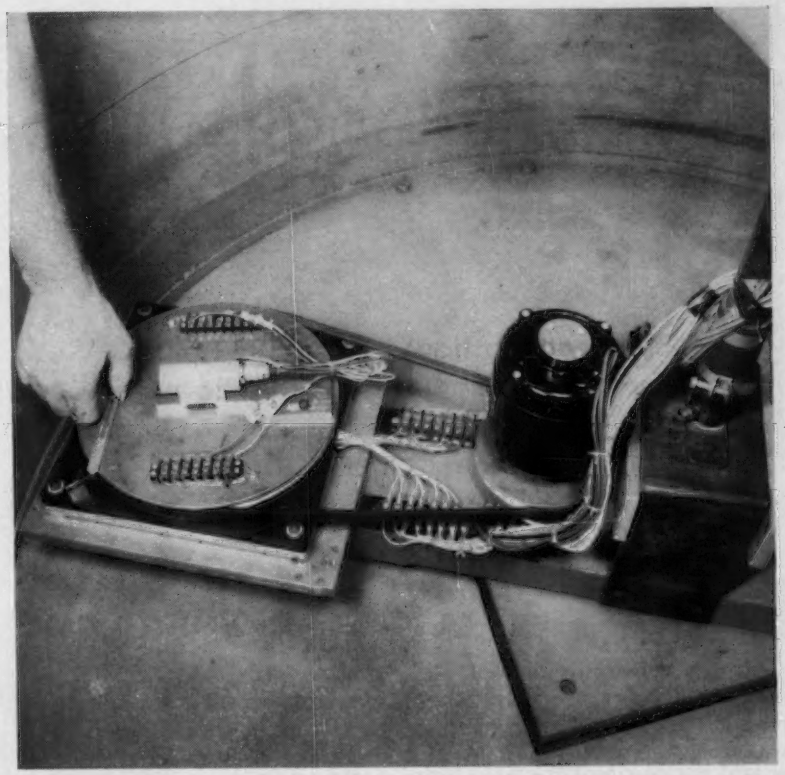
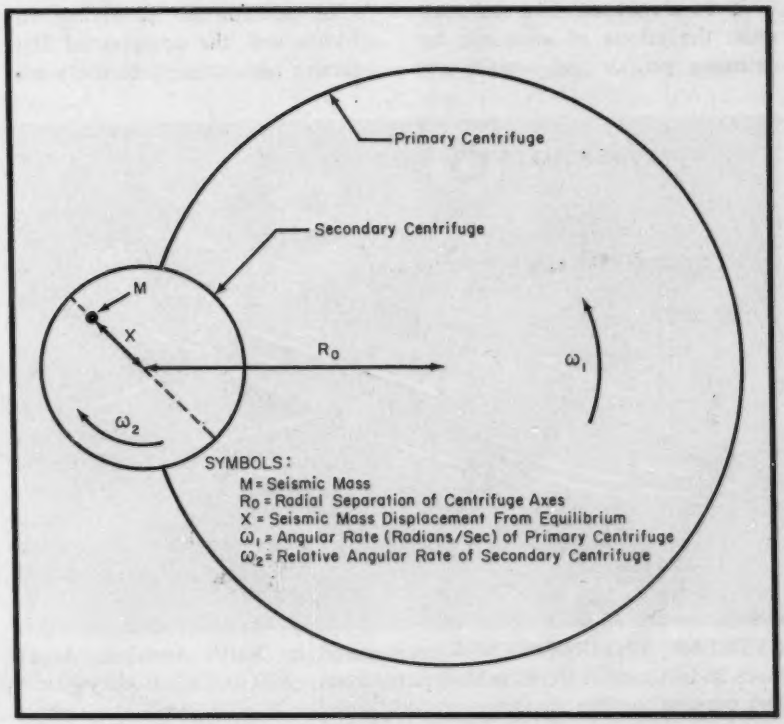


DOUBLE CENTRIFUGE used at Rototest Laboratories, Lynwood, Calif., has secondary centrifuge, drive belt and motor, and slip-ring terminals mounted on primary centrifuge arm. Schematic below illustrates double-centrifuge theory.



X-15 Challenges Seal Designers

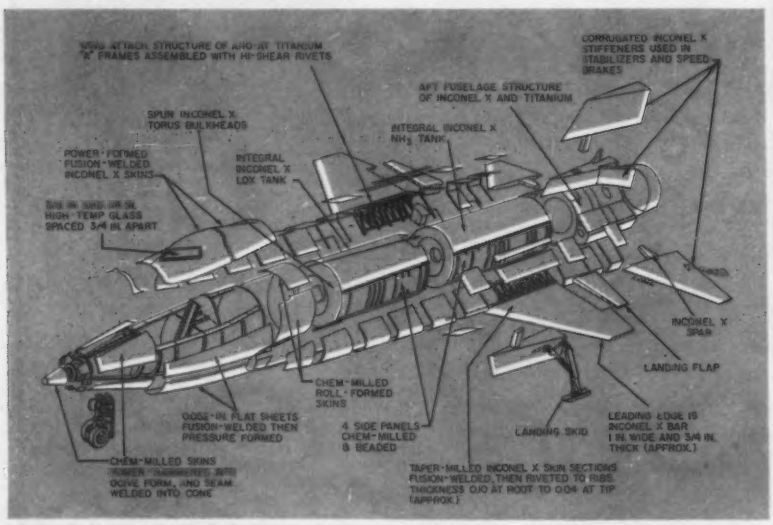
Bulkheads in liquid ammonia tanks made leak-proof with phenolic adhesive-sealer

Designing effective seals to a wide range of temperatures and pressures is one of the general environmental problems on NAA's X-15 research vehicle. Sealing the segmented pressure bulkhead of the liquid ammonia tank is a specific problem.

The segmented pressure bulkheads, consist of Inconel riveted to 7075-T6 aluminum. The seal must resist the effects of ammonia for extensive periods and remain serviceable from −40 to 300°F. Another requirement is that the sealer be capable of being applied and cured at a temperature which will not reduce the strength of the aluminum because of time-temperature annealing effects.

The problem is solved with a thermosetting, elastomer - phenolic film adhesive (Scotch-Weld AF-30).

In addition to providing an effective seal, the unsupported film adhesive adds strength to the joint. It retards joint slippage, fatigue failures, loosening of fasteners, and development of leaks.

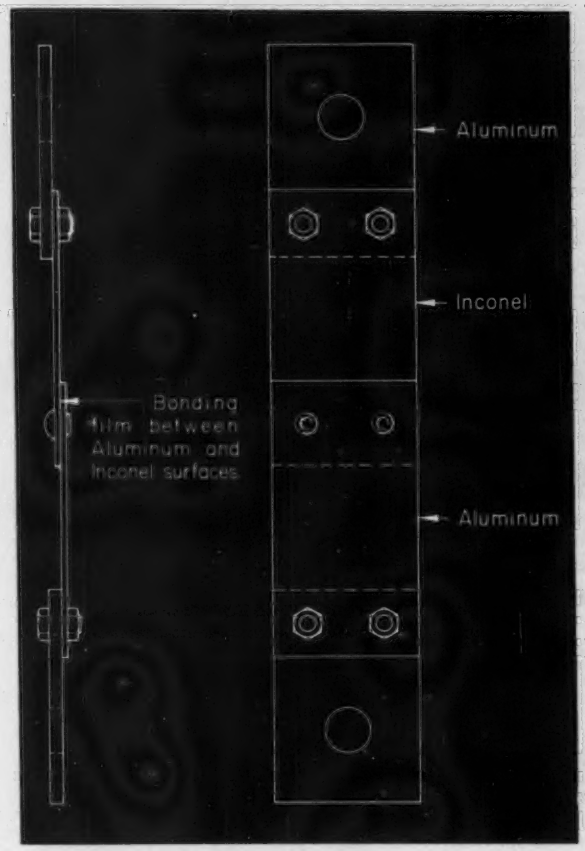

AFT FUSELAGE STRUCTURE OF INCONEL X AND TITANIUM
"A" FRAMES ASSEMBLED WITH HI-SHEAR RIVETS
CORRUGATED INCONEL X STIFFENERS USED IN STABILIZERS AND SPEED BRAKES
SPUN INCONEL X TORUS BULKHEADS
INTEGRAL INCONEL X NH_3 TANK
POWER-FORMED FUSION-WELDED INCONEL X SKINS
INTEGRAL INCONEL X LOX TANK
HIGH-TEMP GLASS SPACED 3/4 IN. APART
INCONEL X SPAR
LANDING FLAP
CHEM-MILLED ROLL-FORMED SKINS
CHEM-MILLED SKINS
4 SIDE PANELS CHEM-MILLED & BEADED
LANDING SKID
LEADING EDGE IS INCONEL X BAR 1 IN. WIDE AND 3/4 IN. THICK (APPROX.)
TAPER-MILLED INCONEL X SKIN SECTIONS FUSION-WELDED, THEN RIVETED TO RIBS. THICKNESS 0.10 AT ROOT TO 0.04 AT TIP (APPROX.)

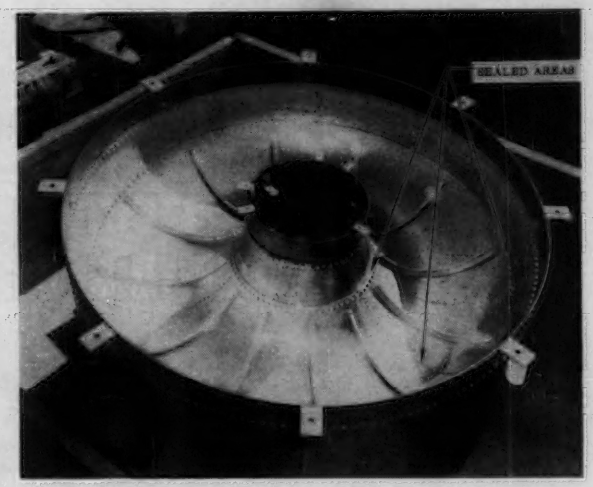
EXTREME ENVIRONMENTS encountered by North American Aviation's X-15 rocket research vehicle range from −300 to 1200 F. Cryogenic fuel presents sealing challenge in tank area.

Sealing Procedure — Procedure for sealing the X-15 liquid ammonia tank starts with a ½ to 1 mil brush coat of EC-1459 primer being applied to all pre-cleaned sealing areas. While the primer is still slightly tacky, AF-30 bonding film is applied to the mating part (either alumium or Inconel) that will receive the least mechanical disturbances after bonding film application.

The film adheres to the primed surface and can be formed to fit most contour sections. In areas where the film cannot be formed to match the contour of the part, one-quarter in. deep V-shaped cuts are made in the bonding film. The wedges are held in position with EC-1459 primer until the mating part is brought into place. Large structural holes are plug-sealed with hand-formed pieces of AF-30 bonding film.

To remove bonding film covering fastener holes, an Osborne revolving punch is used. The hole in the bonding film is undercut to leave a 0.005 to 0.010 in. overlap extending into the hole so that the bonding film will flow along the sides of the inserted fastener. The fastener is thus completely sealed.





▲ **SEALED AREAS** on bulkhead of X-15's liquid ammonia tank are at juncture of Inconel and 7075-T6 aluminum segments.

◀ **JOINT SAMPLE** shows Minnesota Mining and Manufacturing's elastomeric phenolic film adhesive lapped into seal.

When parts are ready for final assembly, the backup liner on the bonding film is removed, and parts are mated carefully so the preplaced bonding film is not disturbed. When the bonding film is spliced between parts, a ¼ in. overlap is used. Parts are aligned exactly before they are brought into contact. All bolts and rivets are then secured.

A leakage check is performed after the mating parts have been assembled, but before the bonding film is cured. For this check, all access doors are closed and the sealed compartment is pressurized with air at a maximum rate of 8 ft^3/min or until a pressure of 2 psi is obtained.

The bonding film is then cured at 300 to 350°F for 2 hr. Thermocouples on the heated section ensure that the temperature does not exceed 350°F. After the bonding film is cured, all bolts are retorqued.

Selection Tests—The test for selecting the proper sealer was performed on a sealed Inconel-aluminum overlap specimen.

Aluminum and Inconel panels were solvent wiped. The bonding film was applied to one panel surface, and the other panel was then riveted in place. In areas where EC-1459 primer was used, the material was painted on the surfaces, air dried for 30 min, and baked at 250°F for 30 min. The specimen film was cured for 2 hr at 350°F, and the prepared flex specimens were then immersed in liquid ammonia for seven days.

Tests began at the end of the seven-day period. When warmed to room temperature, the specimens were flexed twice by application of a tensile load of 1330 lb and then flexed 100 times with a 1200 lb load. Following this, a 100 psi air stream was directed against one side of the seal while the other side was examined with bubble fluid to check sealing. The rivets were then removed, the bond ruptured, and the panel surfaces examined for mode of failure. The sealer was considered to have passed the flexibility test if it did not leak after the flex test and if it failed in cohesion rather than adhesion when the joint was ruptured.

◆

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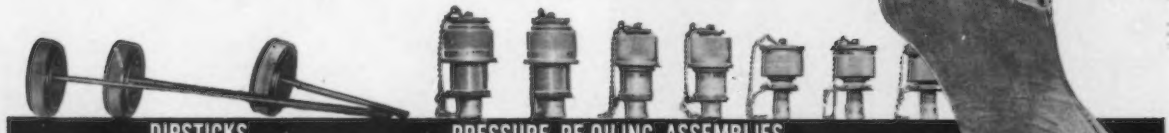

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Pneumatic-powered shock test machine produces up to 3000 G's. It is for production-testing of small electronic components. The machine handles specimen loads up to

30 lb and produces all shock velocity of up to 192 in. per sec. Design employs pneumatic actuation and control of the shock pulses produced.—Avco Research and Advanced Development Div.

Circle 60 on postcard for more data

Resin Stripper

Stripper removes epoxy and polyester resins from potted components 10 times faster than usual devices.

Called "Tele-Solv," it will not corrode, discolor or otherwise affect copper, aluminum, ferrous metals or resin-based enamels.—Telecomputing Corp.

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Environmental Chamber

New temperature test chamber reaches from minus 300 to plus 1000 degrees. Designed to be used with a vibration exciter in combined environmental testing, self-contained chamber is equipped with casters for portability. High temperature operation of this combination chamber is accomplished by electrical heating with temperatures from ambient to +1000°F in 45 minutes. Expendable refrigerants provide the cooling.—Missimers Inc.

Circle 62 on postcard for more data

Pyrometers

Pyrometers measuring temperatures above 3000°F are now offered commercially. These do not use thermocouples and so are free from problems of atmosphere limitations, calibration drift and short life.—Atlantic Pyrometers.

Circle 63 on postcard for more data

Measuring Tape

New tape has micrometer precision; checking diameters of round parts to 0.001 in. accuracy. Only one measurement necessary.—Pi Tape.

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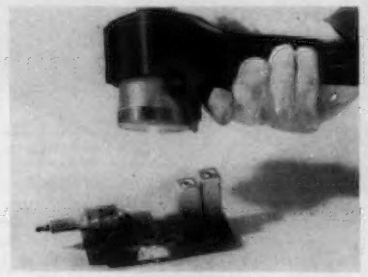
Spray-Gun

Plasma-jet spray gun deposits epoxy resins onto any surface for coatings of virtually any desired



thickness. In addition to exceptional bonding, Plasmadyne engineers claim extreme penetration of the resins with the spray technique.—Plasmadyne Corp.

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continued on page 56

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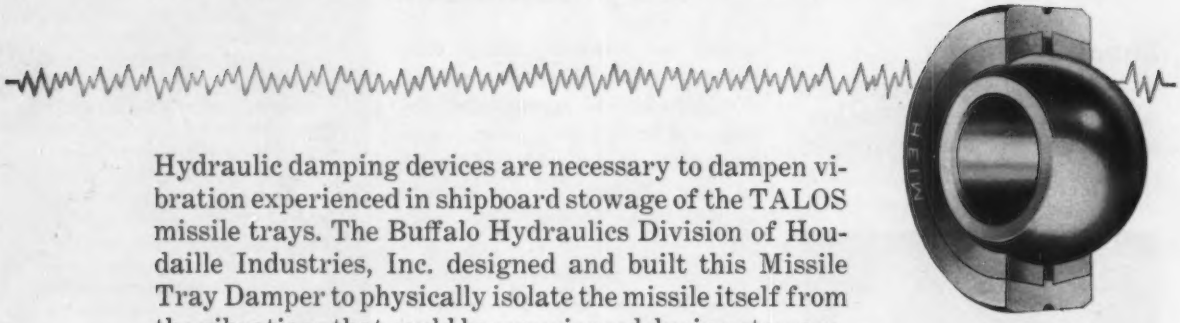


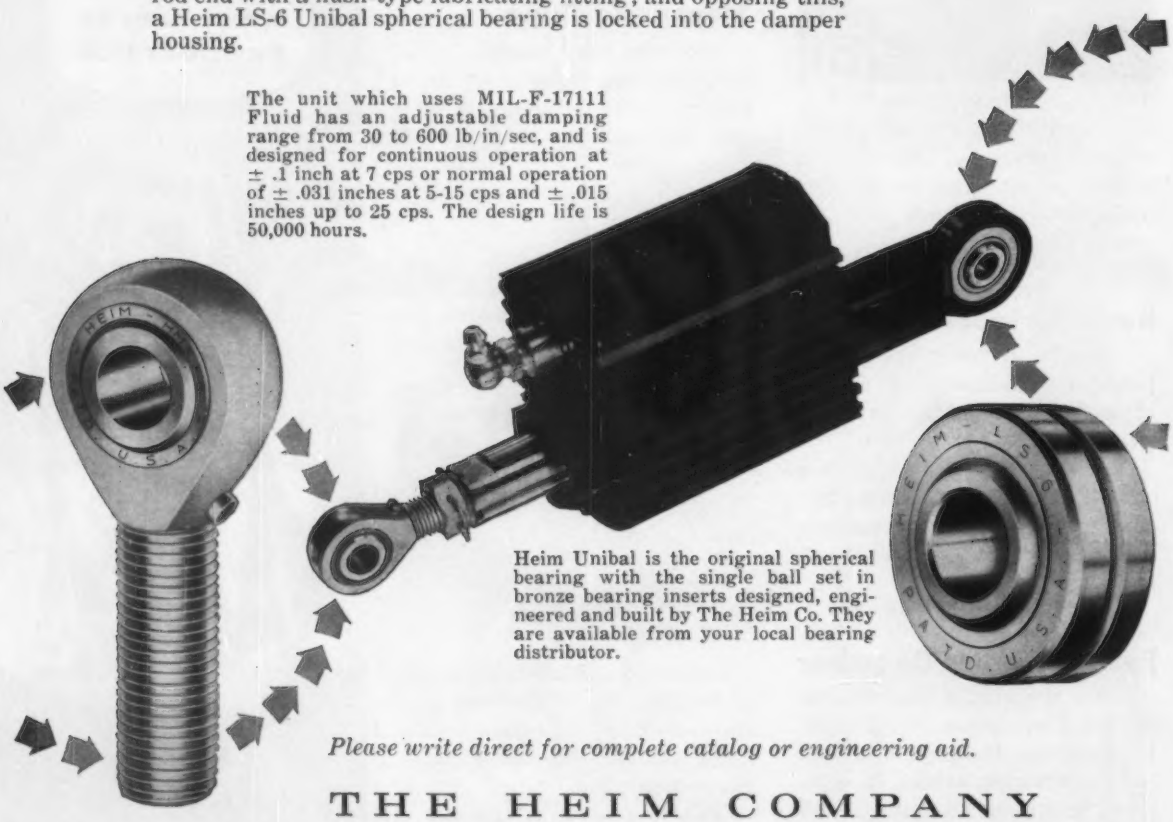
Hydraulic damping devices are necessary to dampen vibration experienced in shipboard stowage of the TALOS missile trays. The Buffalo Hydraulics Division of Houdaille Industries, Inc. designed and built this Missile Tray Damper to physically isolate the missile itself from the vibrations that could be experienced during stowage.

With the misalignment which can be expected of equipment used on shipboard it was necessary to use a reliable, inexpensive self-aligning rod end such as

HEIM *Unibal*® SPHERICAL BEARING

At one end of the damper is a male threaded HMX-6FG Heim rod end with a flush-type lubricating fitting; and opposing this, a Heim LS-6 Unibal spherical bearing is locked into the damper housing.

The unit which uses MIL-F-17111 Fluid has an adjustable damping range from 30 to 600 lb/in/sec, and is designed for continuous operation at ± .1 inch at 7 cps or normal operation of ± .031 inches at 5-15 cps and ± .015 inches up to 25 cps. The design life is 50,000 hours.



Heim Unibal is the original spherical bearing with the single ball set in bronze bearing inserts designed, engineered and built by The Heim Co. They are available from your local bearing distributor.

Please write direct for complete catalog or engineering aid.

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

VĀP-AIR

Form-LITE

HOT AIR IN-LINE VALVES

2" diameter Formlite valve, with solenoid. This size weighs 1.42 lbs. Can be used for many air-flow control purposes.

- Small, compact . . . lowest weight-to-size ratio
- Positive, reliable operation—only one moving part
- Less than .001% leakage
- Widest operating temperature ranges . . . from —65°F. to 850°F.
- Corrosion-resistant materials
- Meets Military Specifications
- Low cost, minimum maintenance
- Fast-acting . . . less than 1 second response time, when desired
- Extremely low pressure-drop

Văp-Air Formlite in-line valves are solenoid-controlled and pressure-actuated. They provide the operational advantages of older, poppet-type valves (fast action and tight closure), with far lower weight-to-size ratio. Weight ranges from 12.5 oz. for 1¼" valve to 2.5 lbs. for 3" valve.

Valves are fabricated of aluminum, corrosion-resistant stainless steel, monel or similar metals. They operate at duct temperatures from —65°F. to 850°F., on duct pressures as low as 2 psi, and as high as 300 psi, or more. Specially designed disc and valve seat insures positive opening and closing, with less than .001% leakage at full pressure.

Formlite valves are used to control jet engine bleed air, anti-icing air flow to engine shrouds, leading edges of wing and tail, windshield defrosting or rain-removal air flow, compartment air-flow, or as safety shut-off valve up-stream from other pneumatic systems.

They have only one moving part, and operate in ambients up to 850°F.

Văp-Air Formlite valves conform to military specifications, have passed required sand, dust, shock, vibration, salt-spray, humidity, and sustained-use tests.

They are made in various duct sizes from ¾" to 4" with various types of end fittings. They can be supplied with any type of connection; made to open or close in less than one second; designed to fail-safe in either open or closed position should power be interrupted. Electrical power requirement (AC or DC) is extremely low. No limit switches are needed.

for complete technical information and applications write:

VĀP-AIR—SPECIALISTS IN AIRCRAFT TEMPERATURE CONTROLS FOR NEARLY 20 YEARS

Entire systems and a complete line of sensors, electronic, magnetic amplifier and transistor controls, precise voltage regulation, static inverters, electro-pneumatic and electro-mechanical valves, advanced in-line pneumatic valves and regulators, electric power controllers and heat exchange equipment—for aircraft, missiles and ground support.

VĀP-AIR THE AERONAUTICAL DIVISION OF VAPOR HEATING CORPORATION, Dept. 50 J
80 East Jackson Blvd., Chicago 4, Illinois

Please send information on Vap-Air Formlite In-Line Valves.

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Proved! New, Better Way to Seal Drilled Holes with . . .

Less weight!

Less cost!

NEW PIN-PLUGS°

Seal simply, positively Prevent costly leaks!

Now — forget conventional, costly methods of sealing holes that serve as flow or pressure passages. The Lee "Pin Plug" is a cylindrical plug with a tapered reamed hole partway through its center and numerous small grooves on its outside surface. Simply place it into reamed hole and drive in the tapered pin until ends are flush. Controlled expansion causes grooves in plug to "bite" into casting and form independent seals and retaining rings. Extensive laboratory tests report no leaks under normal pressures, often show bone dry seals up to pressures of 40,000 psi.

Now successfully and widely used on aircraft and missiles — for pumps, servo valves, regulators, etc. Available steel and aluminum and in both long and short series.

° Pat #2,821,323

LEE Co.

SOME TERRITORIES STILL OPEN FOR QUALIFIED TECHNICAL SALES REPRESENTATIVES.

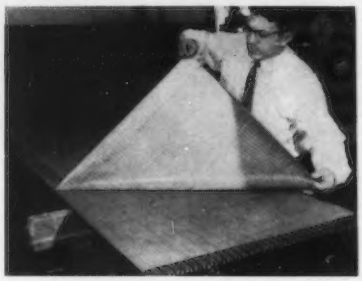
Write today for Standard Sizes and Engineering Data

THE LEE COMPANY OLD SAYBROOK, CONN.

New for Production

Inspection System

Recordaflux, a new magnetic particle inspection system, detects defective welds, cracks, inclusions and other flaws in materials. The



system has special solutions that contain magnetic particles. The patterns show shape and size of a spot, or other type of weld, making it easy to detect a defective joint.—Instrument Div., The Budd Co.

Circle 66 on postcard for more data

Precision Stamping

Model MS-36D U. S. Duplex Multi-Slide is for automatic production of precision formed stampings. This is, in effect, a double-ended machine. Material can be fed in at both ends, one strip feeding in the left to right direction and the other in the right to left direction.—U. S. Tool Co.

Circle 67 on postcard for more data

Red Ring Machines

Six new Red Ring machines are in operation for the first time. These include a rotary gear shaving machine; gear tooth honing machine; pot-type broaching machine; gear speeder with broadband electronic amplifier, new designs of low-cost gear rolling fixtures with charting equipment, and new involute checker.—National Broach & Machine Co.

Circle 68 on postcard for more data

New Electronic Products

Capacitor

Less than ½ in. long and slightly over ¼ in. od—this tubular

capacitor is fully adjustable from 0.8 to 10.0 mmf. Type 2951 precision air capacitor finds application in many missiles, computers, and other electronic devices where fine tuning is needed. More than 10 turns of its adjusting screw are required to cover the complete capacitance range, which varies linearly with each turn. Breakdown voltage is 200 v d-c min.—Johanson Manufacturing Corp.

Circle 114 on postcard for more data

4000°F Temp Sensors

Thermocouple-type temperature sensors have 4000°F capability in oxidizing atmospheres. They are of the non-cooled and cooled types to measure liquid, solid and gaseous temperatures. Capability is accomplished by the use of refractory metals; i.e., tantalum and molybdenum with special CR oxidation resistant coatings. Insulation is magnesia and beryllia and thermocouple wires are iridium, tungsten, rhenium and alloys of these elements.—Aero Research Inst. Co.

Circle 115 on postcard for more data

Shock Accelerometer

Subminiature piezoelectric accelerometer is designed for special shock and vibration test applications where weight is a prime consideration. It is stainless steel. Is only ¼ in. high; weighs just 1.0 gram. The unit has a sensitivity of 2.5 pk-mv/pk-g and a frequency response of 5 cps to 10 kc with its resonant frequency at 135 kc. Maximum acceleration is given at 40,000 g.—Columbia Research Lab.

Circle 116 on postcard for more data

Solid-State Transducer

Pressure transducer combines the best overall characteristics of both strain gauge and potentiometer types. It uses a semi-conductor strain gauge sensor, possesses high accuracy and environmental capabilities. Unit produces a high-level DC output signal that eliminates need for impedance-matching or signal amplification.—Fairchild.

Circle 117 on postcard for more data

Infrared Calibration

System simultaneously compares infrared sources with a secondary standard reference source. Sources up to 12 inches in diam., 50 lb. weight may be calibrated over a

temp range from 50°C to 600°C.

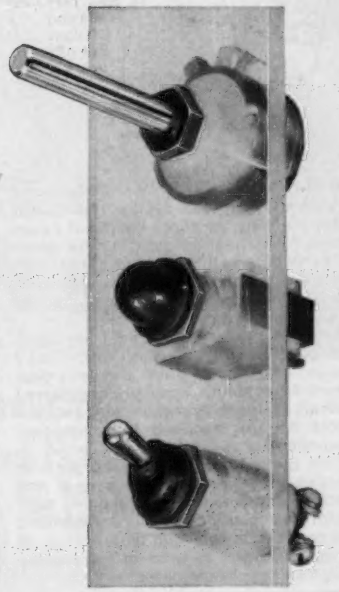
System uses Model PE 537-1 comparator which alternately pictures two apertures at a single field image plane. Energy in this image is then focused on an infrared-sensitive detector.—Perkins-Elmer Corp.

Circle 118 on postcard for more data

APM HEXSEALS*

Modular

SWITCH and SHAFT SEALS



- Fit all industrial electrical controls.
- Meet Military Specifications: MIL-B-005423A (ASG), MIL-B-19257 (Ships), SCL-6303 (Sig. Corps), Par. 183.10-20, Part (B) U.S. Coast Guard.

SEND FOR CATALOG 359A-20

describing items above, also seals for circuit breakers, indicator lights and other electronic components.

*TRADE MARK

A.P.M. Corporation

252 Hawthorne Ave., Yonkers, N.Y.

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Designers and Manufacturers of

HIGH PRESSURE STATIC AND MOVABLE SEALS

HEXSEALS* • SEELSKREWS*

SEELBOLTS* • SEELRIVITS*

Circle 53 on Inquiry Card

AIR He N

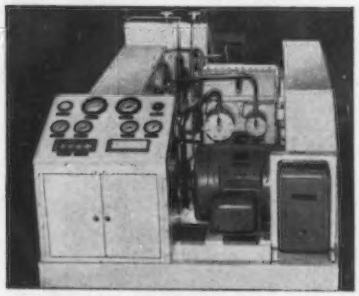
COMPRESSION to
12,000 psi
...discharge capacities
to 150 scfm
with
CARDAIR
CENTRAL COMPRESSION SYSTEMS

New Technical Data and Catalog. See offer below.

Cardair Central Compression Systems (completely packaged, semi-portable)—are today handling air and a variety of gases—helium, nitrogen, argon, etc.—at pressures ranging from 4,000 to 12,000 psi with discharge capacities from 50 to 150 scfm. Even hydrogen is being safely compressed to elevated pressures.

Systems can be provided from stock with *guaranteed* purification of delivered gas to —100°F. dew point and less than 4 ppm oil content. Specially engineered systems to meet your particular requirements can be supplied from standard components.

This performance is *demonstrated* by exacting rocket and missile service and continuously growing use by prime contractors, suppliers of missile components and controls, and testing laboratories. It is *backed* by over 20 years of compressor design and application experience.



Model PB-CCS—*One of a wide selection of systems* 4-stage air-cooled Compression System—Pressure Range: 6,000—12,000 psig—Induction: 65 to 135 psig—Capacity: 75 scfm N_2 and Air; 70 scfm He—Guaranteed Gas Purity: —100°F. Dew Point, less than 4 ppm oil content.

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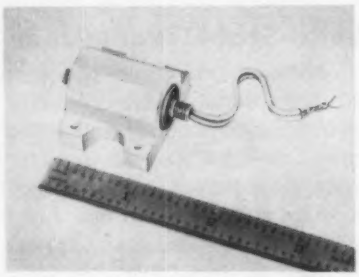
Circle 24 on Inquiry Card

New Electronic Products

No Moving Parts

Miniature explosive switch has no moving parts. Unit has a reliability factor of 99.997 per cent, and is unaffected by normal missile environments. Operation is simple.

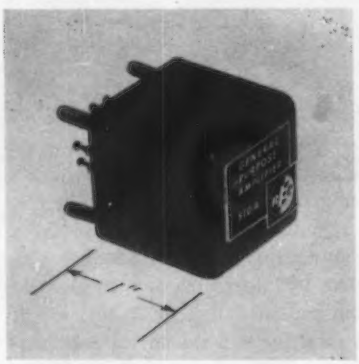


The action of an explosive charge establishes a large-area permanent contact, providing virtually failure-proof of the circuit. It is suitable for temperatures from —100 to 400°F.—Minx Corp.

Circle 69 on postcard for more data

Transistorized Modules

Encapsulated in a rubber-filled, hermetically-sealed steel can, the modules weigh 1.8 to 2.2 oz, and measure 1 $in.^3$ excluding leads. They are aimed to eliminate routine subcircuit design time. Modules are for use as components in electronic systems. All units are suited



to high temperature (—55° to 125°C) and high environmental (MIL-E-5272 and MIL-E-8189) use. Silicon transistors and diodes are utilized throughout.—Rosement Engineering Co.

Circle 70 on postcard for more data

Memory Drum

One hundred thousand bits of information can be stored on 6 oz. memory drum. Data is recorded on the magnetic surface of the tiny stainless steel drum. Drum is 3 in. long and has 3 in. diam. "Shell" design concentrates the drum's mass at the surface. Design, therefore,

provides maximum strength and rigidity with minimum weight.—IBM.

Circle 71 on postcard for more data

Rotary Switch

Electromagnetic stepping switch consists of a high-speed stepping motor and printed circuit switch decks. This series 9C Cycleswitch

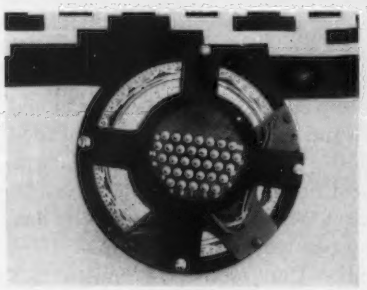
continued on next page

is designed for true digital behavior up to 240 steps or 12 rev/sec. It has no retchets, pawls, mechanical stops or brushes; it has an operating life averaging 25-million revolutions with light loads and adequate arc suppression. Switch decks and brush arrangements as needed. Operating power from ⅓ to 40 watts; current carrying capacity is 1.5 amps at 250 VDC.—Sigma Instruments.

Circle 72 on postcard for more data

Shaft Encoder

Shaft position encoder provides 1024 counts per shaft rotation. Device uses an output in Gray Code and is packaged in a standard BuOrd Size 33 synchro mount. The



Gray Code configuration gives a non-ambiguous output signal without the need for V-Scan or other complicated circuitry at a consequent saving in size and cost.—Norden Div. United Aircraft Corporation.

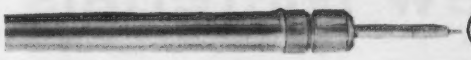
Circle 73 on postcard for more data

Pressure Switch

Featherweight, precision pressure switch weighs only one-quarter oz yet operates at pressures up to 500 psi. Popular use is for indicating full charge of primary missile batteries. Switch senses preset pressure conditions and operates an electrical contact when batteries are fully charged and ready to fire.—B. F. Goodrich.

Circle 74 on postcard for more data

Another "impossible" job done by the Airbrasive...



...lapping steel

abrading • cutting • deburring • stripping • drilling • cleaning • scribing

Eclipse-Pioneer found: Airbrasive reduces lapping time from eight hours to 15 minutes!

When Eclipse-Pioneer, Division of The Bendix Corporation, hand-lapped shallow inclines in these alloy steel thrust bearings to depths of 0.0002" to 0.0004", it took *eight hours* of laborious effort.

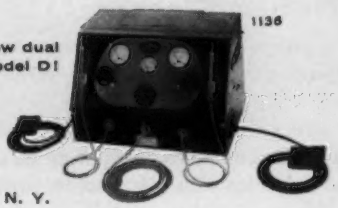
The S. S. White Industrial Airbrasive "does a better job... *and takes 15 minutes!*" they tell us.

Here is a unique industrial tool of many uses... cutting semiconductors... adjusting microelectronic circuits... removing microscopic burrs... cleaning surfaces... and many others. It performs its magic with a superfine stream of abrasive particles and propellant gas that quickly cuts almost any hard, brittle material.

Important too... The Airbrasive is available at a cost you can afford... Under $1,000.00!

Send us samples of your "impossible" jobs and we will test them for you at no cost.

SEND FOR BULLETIN 6006
... complete information.



S. S. White
S. S. White Industrial Division
Dept. 18A, 10 East 40th Street, New York 16, N. Y.

Circle 25 on Inquiry Card

New Materials

Coating Process

New metal deposition process is called "plasmionic monocrystalline film deposition." It is accomplished in a high vacuum under closely controlled conditions. It can deposit numerous alloys and other materials onto such substrate material, as ceramic, glass, Bakelite, Teflon, Mylar, fiberglass, quartz, mica, or any material having a smooth relatively non-porous surface. Process is used in producing electronic devices.—Atohm Elect.

Circle 122 on postcard for more data

Laminate For Electronics

Flame-retardant laminated plastic is recommended for printed circuit and other electronic applications. The glass-base laminated plastic has an epoxy resin binder. It can be furnished with copper cladding on one or both sides, in standard foil thickness. Meets all the requirements of MIL-P-13949-B.—Synthane Corp.

Circle 123 on postcard for more data

N_2O_4 Seal Compound

An elastomeric compound for use with nitrogen tetroxide (N_2O_4) has been developed. Called B496-7, it has proven to be the most satisfactory material as yet developed by this seal manufacturer for use with the new missile propellant.—Parker Seal Co.

Circle 124 on postcard for more data

Plating Cleaner

Alkaline plater's cleaner eliminates the hazardous acid pickling process for rust removal in electroplating. Called "Surj," the new product combines heavy duty cleaning abilities with light rust-removing properties for use electrolytically or as a soak tank cleaner. It has a high conductivity in solution, so it cleans the surface of the work and penetrates deeply into pores. Requires no extra equipment. Can be used in either hard or soft water in mild steel tanks.—Turco Products Inc.

Circle 125 on postcard for more data

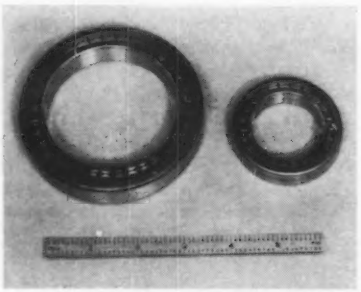
Pure Gold Laminate

A laminate of 24 K gold on rubber-coated Nylon has been developed. It has been long sought because of golds' desirable properties. Material is both steril and radiation repellant. It can be made in continuous rolls 36 in. wide, 100 yards long.—Lamart Corp.

Circle 126 on postcard for more data

Hot-Bearing Steel

Special grade of stainless steel (Lesco BG 41 Vac Arc) is being used for bearing in the thrust reverser on Boeing's 707. The material is subjected to a maximum



compressive stress of more than 600,000 psi and temperature elevations in excess of 800°F as the giant airliners are brought to a stop. —Latrobe Steel Co.

Circle 127 on postcard for more data

Cutting Fluid

Cutting fluid and coolant formulated for severe machining and grinding operations is now being marketed. Case histories are interesting. Called Trim H.D., it is a white jell diluted with water. It causes no odor, no rancidity, no gumming, no skin irritation. Face of the work is clearly visible through the translucent fluid.—The Master Chemical Corp.

Circle 128 on postcard for more data

Oil-Grease Additive

Additive combats high-temperature deterioration in lubricating oil. Also reduces bearing corrosion. Designated UOP-225, it contains no metal or phosphorous, is stable at temperatures above 500°F and leaves no combustion ash. It is completely soluble in petroleum and synthetic lubricants. Recommended doses: 1 to 2 per cent for diabasic acid or polyol derived lubricants to meet MIL-L-9236A; and one-half to one per cent for MIL-L-7807 oils.—Universal Oil Products.

Circle 129 on postcard for more data

Porous Nylon Parts

Porous nylon parts which absorb 15 to 50 per cent of oil by weight have been developed. The oilfilled nylon parts are claimed to hold the oil under extremes of pressure, temperature and acceleration. Approximately 20 per cent of the oil is retained even after centrifuging at 15,000 G's.

Known as micro-porous Nylasint 64HV, the parts are formed by cold pressing and sintering nylon powders by techniques similar to those used in powder metallurgy. The oil-filled nylon is claimed to operate for very long periods at a frictional coefficient as low as 0.01.

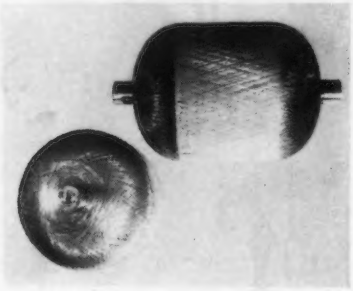
Parts can be used as bearings at PV's (pressure × velocity) of 40,000 to 70,000.—Polymer Corporation.

Circle 130 on postcard for more data

New Materials

Strong Pressure Vessels

Pressure vessels having a strength-density ratio in excess of 3 million in.-lb/lb have been made. They employ filament winding and have integrally-wound end closures. This corresponds to a undirectional



strength of 340,000 psi in the fiber-resin system. Developer has built a special helical filament-winding machine with a capacity for vessels of 72 in. diam. and 150 in. length.—Tapco Group, Thompson Ramo Wooldridge.

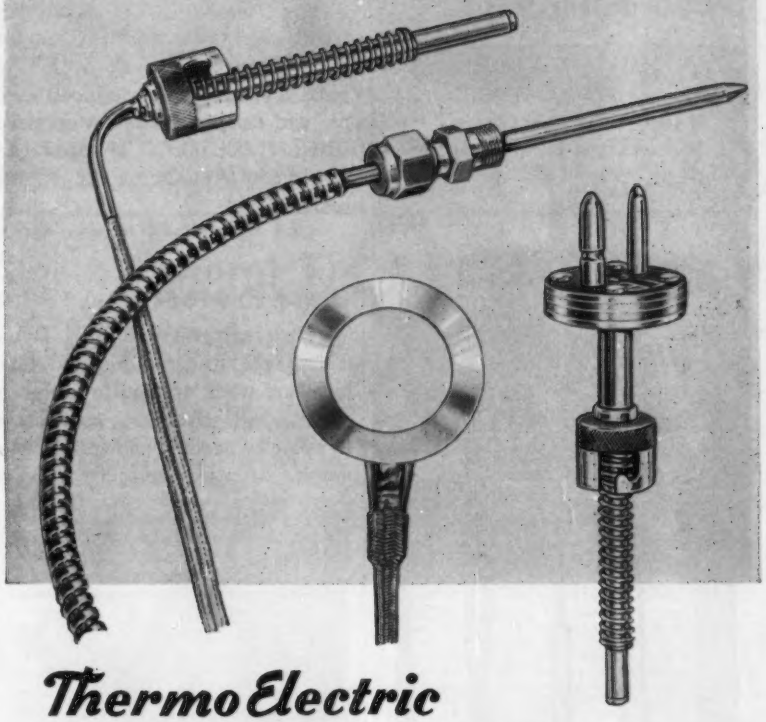
Circle 75 on postcard for more data

Test Meteorites

Artificial meteorites made of ceramic are used in ground tests of space vehicles. The tiny particles duplicate the effects of actual meteorite bombardment in space. Tests are carried out by firing ceramic particles from test guns at extremely

continued on next page

Peak Performance—
economy on the job!



ThermoElectric
Miniature Thermocouples

You can obtain a Thermo Electric Miniature Thermocouple for peak performance and economy in almost every application! Those illustrated are available in a wide variety of sizes, standard thermocouple materials, adapt to many applications.

Protected thermocouples are extremely sensitive, give fast response to minute temperature changes. The measuring junction is welded or silver soldered to the tip of the thin-walled "Ceramo" metal sheath. Ideally used in corrosive liquids or gasses—and many pressure applications. For quick-coupling versatility, the spring-loaded bayonet-lock thermocouple is tops! You can use one "couple" at various depths with different adapters. With spring-loading, tip contact is always maintained. The bayonet type is highly sensitive, fast responding, for use in pump and engine cylinder heads, turbine housings, pipes, electric motors, generators, plastic extruders and molding machines.

Gasket Thermocouples measure surface temperatures in all sorts of stationary or moving machinery.

T.E. also produces stagnation, exposed junction and shielded thermocouples for use in air, gas or vaporous atmospheres.

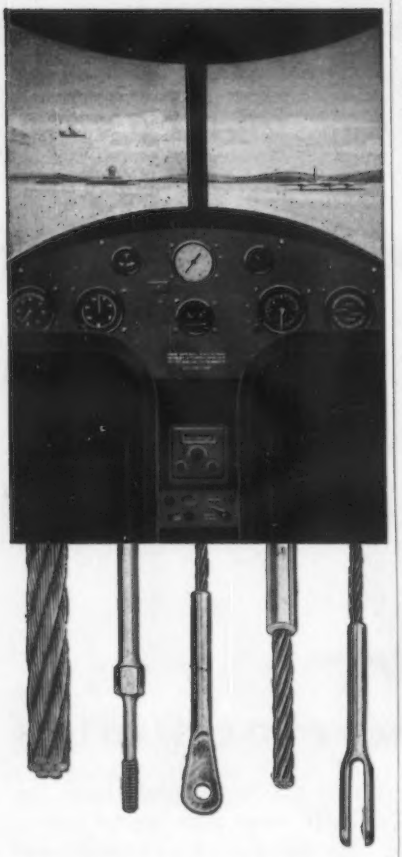
write today for Bulletin 1256-1

Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

Circle 26 on Inquiry Card

"Information Center" for **Roebling Aircord**



Here is where the immediate response of Roebling Aircord is felt. Roebling Aircord – tinned, galvanized carbon and stainless – is made to exceed *military* specifications.

Roebling Aircord is made in a full range of sizes and constructions. Cord can be furnished in stock lengths or in complete assemblies... fittings are available for every requirement. Lock-Clad, preformed cable with aluminum tubing swaged around it, is also produced by Roebling... the original producer, and for many years the only producer.

For further information on Roebling Aircord, write to Wire Rope, John A. Roebling's Sons Division, Trenton 2, New Jersey.

ROEBLING

Branch Offices in Principal Cities
John A. Roebling's Sons Division
The Colorado Fuel and Iron Corporation

Circle 27 on Inquiry Card

New Materials

high velocities. A meteorite travelling at 100,000 ft/sec would perforate radiators used in nuclear powerplants. The ceramic has an axial compressive strength of 15,000 psi and can withstand an acceleration of 1,000,000 G in a test gun. —Electric Autolite, Ceramic Research Lab.

Circle 76 on postcard for more data

Blast Protector

High temperature coating, Dyna-Therm 65, resists flame and blast exposure when applied to umbilical cables and electrical connectors. Graphic evidence is shown in photograph. After exposure, a portion of

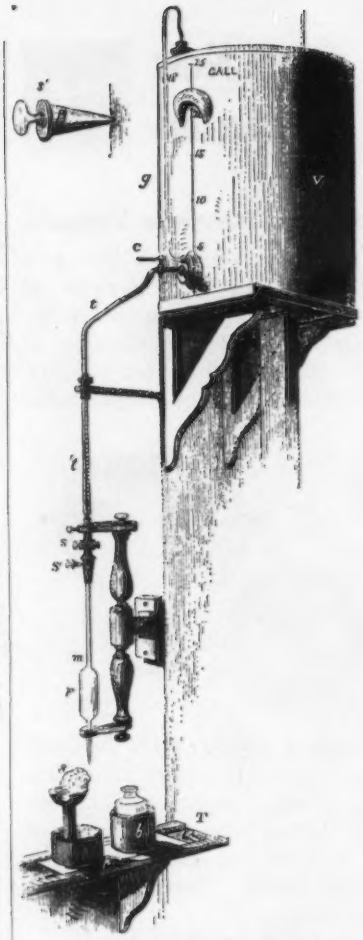
the coating was cut away. No scorching or other apparent damage was found. Paper stamps under the coating were not scorched and were legible.—Dyna-Therm Chemical Corp.

Circle 77 on postcard for more data

Indium Clad Aluminum

Aluminum, clad on both sides with indium, is available for use in forming alloy junctions in germanium semiconductor devices. Process employed produces parts with a true metallurgical bond. This means no aluminum oxide is present at the interface. During the semiconductor alloying operation the indium covers the aluminum and prevents the oxide from forming, as well as acting as a carrier into the germanium.—Accurate Specialties Co.

Circle 78 on postcard for more data



PHYSICAL SCIENCES

Another area of advanced inquiry at UTC

A comprehensive study of the basic phenomena in propulsion systems and their interaction with the environment is being conducted by a staff with unusual capabilities at United Technology Corporation's new multi-million-dollar research and development complex in the San Francisco Bay Area.

Specifics under investigation include:

- Steady and non-steady burning of solid composite and liquid propellants
- Detonation and explosive phenomena
- Aerothermodynamics of nozzle performance of two-phase gases involving the study of transport phenomena, adiabatic expansion laws, nucleation, phase lag, and radiation.

New concepts of major significance are evolving from this research.

UTC **UNITED TECHNOLOGY CORPORATION**

A subsidiary of United Aircraft Corporation

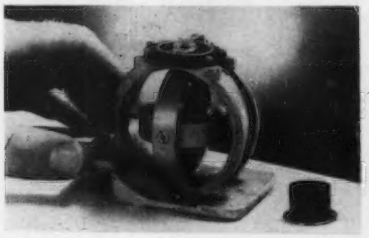
P. O. Box 358 • Sunnyvale, California

Circle 28 on Inquiry Card

New Parts and Components

Pyrotechnic Gyro

Smaller than a baseball, gyro is driven by 3 gram charge, reaches 36,000 rpm within 0.1 sec. It performs effectively up to 4 min. The

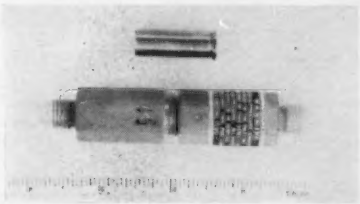


propellant grain operates in temperatures from −65° to 71° C. Intended for short-range missiles.—Giannini Controls Corp.

Circle 79 on postcard for more data

Delay Initiator

Ballistic delay initiator was originally developed for seat ejection system of T2J trainer. Fired by a gas pressure input of 400 to 500 psig, this 1½-oz unit generates a pressure of 2000 psig in a closed volume of 0.3 cu in., after a delay of ½ second. Special .38



caliber cartridge used can be modified for various delays and/or pressure outputs, to suit. With either delay or instantaneous cartridges, initiator also serves effectively as a pressure booster in long ballistic gas transmission lines. — Chromalloy Corp.

Circle 80 on postcard for more data

Aircraft Heater

Dual auxiliary heater meets FAA standards. Initial application was

continued on page 65

FPD PROFESSIONAL EMPLOYMENT NEWS

PUBLISHED BY THE FLIGHT PROPULSION DIVISION OF GENERAL ELECTRIC IN CINCINNATI, OHIO / OCTOBER, 1960

FPD NEWS offers latest information on openings throughout the Division to interested engineers and scientists. Technical information and news relating to current projects will also appear from time to time in this column.

General Electric Forms New Space Power Operation

A new Space Power Operation has been formed by the Flight Propulsion Division to consolidate advances achieved in space power and propulsion during the past 3-4 years. The move will join in a single organization the design and development of systems to power accessory equipment and electrical propulsion engines for advanced outer space vehicles.

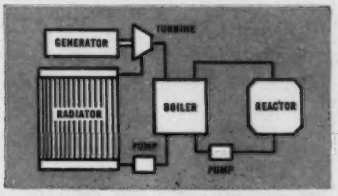
According to FPD General Manager David Cochran, "Progress in the space power field has developed to the point where an organization of this nature can most fully utilize the technology being created." He added that the Space Power Operation would integrate new projects into company-wide space efforts.

Nuclear Power Stressed by Operation Manager

M. A. Zipkin, who previously guided FPD's advanced propulsion systems activities as Manager of Thermodynamics, will head the Space Power Operation. Commenting on the work of his new group, Mr. Zipkin emphasized the high efficiency potential of nuclear-powered turbomachinery.

Investigations already underway are centered on nuclear turbogenerator systems using high temperature liquid metal as the working fluid.

Other future requirements for space power systems have been defined to include power sources for manned and unmanned vehicles on interplanetary probes, lunar-based power sources, power for large orbiting satellites and powered relay communications stations.



Simplified schematic of potassium two-phase power supply. Primary loop carries heat from the reactor to boiler heat exchanger by means of high temperature, high pressure liquid metal. In the boiler, fluid flowing in the second loop is completely vaporized, expands through a turbine driving the electric generator and system pump, passes on to the radiator for condensation and return to the boiler.

Diversified Programs Offer Many Opportunities

Programs of continuing importance at FPD include further development of the J93 engine, to power the B-70 and the CJ-805-23 aft-fan turbojet destined to see commercial airline service next year. Progress in Lift Fan development, new engines and applications, rockets and space propulsion document the greater opportunities for professional achievement at FPD.

Immediate Openings in Space Power Operation and Other Expanding Areas

Liquid Metals Systems / Physical & Analytical Chemistry / Electrical Control Components Design / Engine Controls Systems Design / Thermodynamic Cycle Design Analysis / Metallurgical Engineering / Turbomachinery Design / Ion & Plasma Propulsion / Liquid & Solid Rocket Development

For more information, write informally, or forward your resume in confidence to Mr. Mark Peters, Dept. 125-MJ.

FLIGHT PROPULSION DIVISION

GENERAL ELECTRIC

BUILDING 100 CINCINNATI 15, OHIO

Circle 202 On Inquiry Card

HANDY ALLOY DATA SHEET

HANDY & HARMAN ENGINEERING DEPARTMENT
82 FULTON STREET, NEW YORK 38, N. Y.

ALLOY LIST

Handy & Harman Silver Brazing Alloys

...The COMPLETE line that meets all specifications and production needs

Need to join any combinations of metals—ferrous and nonferrous? Investigate the vast number of products, assemblies and parts that are being joined better by silver brazing alloys. Handy & Harman, the Number One Source of, and Authority On Brazing Alloys and Methods makes—and makes readily available—the following silver brazing alloys:

HANDY & HARMAN SILVER BRAZING ALLOYS

NAME	COMPOSITION PERCENTAGE				MELTING POINT		FLOW POINT		TROY OUNCES PER CU. IN.
	Ag	Cu	Zn	Other	°F	°C	°F	°C	
EASY-FLO	50	15½	16½	(18 Cd)	1160	625	1175	635	5.0
EASY-FLO 3	50	15½	15½	(16 Cd-3 Ni)	1170	630	1270	690	5.0
EASY-FLO 45	45	15	16	(24 Cd)	1125	605	1145	620	4.9
EASY-FLO 35	35	26	21	(18 Cd)	1125	605	1295	700	4.9
SIL-FOS	15	80		(5 P)	1185	640	1300	705	4.5
SIL-FOS 5	5	88¾		(6¼ P)	1185	640	1300	705	4.4
TEC*	5			(95 Cd)	640	340	740	395	4.6
TEC-Z*	5		16.6	(78.4 Cd)	480	250	600	315	4.5
BRAZE 071 (SN #7)†	7	85		(8 Sn)	1225	665	1805	985	4.8
" TL	9	53	38		1410	765	1565	850	4.5
" ATT	20	45	30	(5 Cd)	1140	615	1500	815	4.6
" 202 (AT SPEC)†	20	45	35		1315	715	1500	815	4.7
" NE	25	52½	22½		1250	675	1575	855	4.7
" 251 (AE)†	25	57½	17½		1270	690	1625	885	4.7
" NT	30	38	32		1250	675	1410	765	4.7
" DT	40	36	24		1235	670	1415	770	4.8
" SS	40	30	28	(2 Ni)	1220	660	1435	780	4.8
" 404 (SS-5)†	40	30	25	(5 Ni)	1220	660	1580	860	4.7
" DE	45	30	25		1225	665	1370	745	4.8
" ETX	50	34	16		1250	675	1425	775	5.0
" 541 (4772)†	54	40	5	(1 Ni)	1340	725	1575	855	5.1
" 560 (ER)†	56	22	17	(5 Sn)	1145	620	1205	650	5.0
" 580 (EB)†	57½	32½		(7 Sn-3 Mn)	1120	605	1345	730	5.1
" RT	60	25	15		1245	675	1325	720	5.0
" 603 (RT-SN)†	60	30		(10 Sn)	1115	600	1325	720	5.2
" 630 (RSNI)†	63	28½		(6 Sn-2½ Ni)	1275	690	1475	800	5.1
" EASY	65	20	15		1240	670	1325	720	5.1
" 655 (RE-MN)†	65	28		(5 Mn-2 Ni)	1385	750	1560	850	5.2
" MEDIUM	70	20	10		1275	690	1360	740	5.1
" BT	72	28			1435	780	1435	780	5.2
" HARD	75	22	3		1365	740	1450	790	5.3
" 752 (TR #1)†	75		25		1300	705	1330	720	5.1
" IT	80	16	4		1340	725	1490	810	5.3
" 852 (85 Ag-15 Mn)†	85			(15 Mn)	1760	960	1780	970	5.1
PREMABRAZE 610	61	24		(15 In)	1155	625	1305	705	5.0

*A Solder—Not a Brazing Alloy. †Former Names

Space does not permit listing the many special alloys, formulated for a particular or unique application. Handy & Harman Brazing Engineers and Technical Service are always ready to work closely with you on metal joining problems and methods.

Comprehensive technical literature covering all aspects of brazing methods and alloys awaits your request.

GET THE FACTS FROM BULLETIN 20

This informative booklet gives a good picture of silver brazing and its benefits...includes details on alloys, heating methods, joint design and production techniques. Write for your copy.

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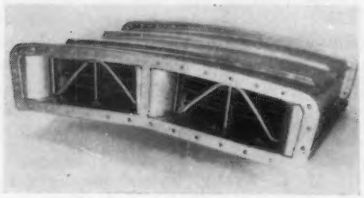
DISTRIBUTORS IN PRINCIPAL CITIES

New Parts and Components

. . . continued from page 63

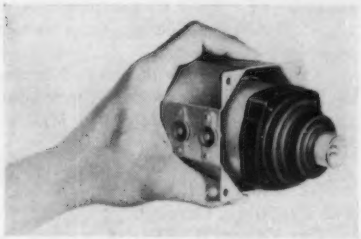


in the Convair 880 and 600 jet airliners. Supplying 7½ KW of heat each, heaters are housed in a welded aluminum structure with a series of elements, connected for 3-phase, 200-volts, 400-cycle power. Heating is controlled by varying the effective heater voltage. — Electro Products.

Circle 81 on postcard for more data

Shock Mounts

Elastomeric mounting system protects small equipment and instruments against dynamic disturbances in jet aircraft. System provides all-attitude control of high-frequency excitations plus attenuation of shock and structure-borne noise. Their efficiency remains constant from −65° to 300°F. Will accommodate different shapes and all instruments



meeting ARINC 408. Applications include transducers, pressure transmitters, indicators, gages, potentiometers, electronic tubes, warning and timing devices and baro-switches; performance is unaffected by fungi, dust, sand, salt atmosphere, oil and ozone.—Lord Manufacturing Co.

Circle 82 on postcard for more data

THIS COUPON WILL BRING YOU A VALUABLE BOOKLET ON TESTING WITH CARDOX CO_2. SEE OFFER BELOW.

Get the facts on CO_2 Testing

CARDOX®

PIONEERS OF CO_2 FOR ENVIRONMENTAL TESTING

-100°F. IN SECONDS WITH ABSOLUTE CONTROL—yours with a Cardox Bulk Liquid CO_2 Storage Unit installed, serviced and maintained on your premises. Exclusive, patented CARDOX CO_2 VAPOR RECYCLE SYSTEM insures maximum cooling effect of carbon dioxide at point of use—at all times. Cardox carbonic gas and dry ice also available in any quantity to suit your specific testing needs.

MAIL THIS COUPON, attached to your signed letterhead, to Cardox. You will receive your copy of a new, illustrated booklet which fully describes the various methods of testing with CO_2 in use today, and shows how Cardox CO_2 Vapor Recycle System can bring new economy, efficiency and reliability to your operation. Send for your copy today.

CARDOX PRODUCTS: Carbon Dioxide Fire Extinguishing Systems, Trucks, and Foam Fire Equipment . . . Liquid Carbon Dioxide . . . Carbonic Gas . . . Dry Ice.

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Dept. 1635-R, 840 N. Michigan Ave., Chicago 11, Ill.

Regional offices: Jersey City, N. J. 26 Journal Square; Memphis, Tenn. 784 Mississippi St.; Detroit, Mich. 1723 W. Lafayette Blvd.; Chicago 9, Illinois 43rd & Marshfield; Fort Worth, Texas 825 N. Calhoun St.; Los Angeles, Cal. 151 North Avenue 19

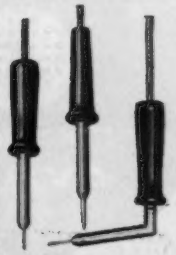
Circle 30 on Inquiry Card

NOW in 50 WATTS for MINIATURE and SUBMINIATURE PRODUCTION SOLDERING JOBS

the *NEW*, American Beauty BANTAM "X" series

Designed with 50 watt input, these fine soldering irons will give greater productivity and do industry's most exacting soldering jobs easier, faster, better. SLOTTED STAINLESS STEEL CASINGS MAKE THE HANDLES REALLY COOL, ending operator complaints. There's no waiting or fumbling with these light, flexible tools — they're always ready. American Beauty soldering irons are known the world over for their dependability, durability and efficiency. Learn more about these fine soldering tools today.

Shown below are other shapes and tip-size irons available in the BANTAM "X" series.



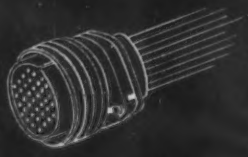
YOU CAN'T BEAT A SOLDERED CONNECTION

WRITE FOR DESCRIPTIVE CATALOG SHEET, FORM NO. 222-CT

AMERICAN ELECTRICAL HEATER COMPANY
DETROIT 2, MICHIGAN

Circle 31 on Inquiry Card

BENDIX
MS-R
ENVIRONMENT RESISTANT
Connectors



Bendix MS-R series are the small, lightweight, more efficient and compatible environment resisting class of connectors as specified in the latest version of MIL-C-5015.

Main joint and moisture barriers at solder weld ends have integral "O" rings. Grommet design of "slippery rubber" is sealing medium for individual wires. This provides easier wire threading and friction-free travel of grommet over wires.

Many other features are described in MS-R Bulletin. Send for your copy today, or

Call your Avnet Applications Engineer

For dependable service

and immediate delivery

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AVNET•45 Winn St., Burlington, Mass.-BR 2-3060
AVNET•4180 Kettering Blvd., Dayton 39, Ohio-AX 8-1458
AVNET•2728 N. Mannheim Rd., Melrose Park, Ill.-GL5-8160
AVNET•1262N. LawrenceSta. Rd., Sunnyvale, Cal.-RE6-0300

Circle 32 on Inquiry Card

Men on the Move

A. E. SCHWERIN, named head of a Skybolt re-entry vehicle program at General Electric's Missile and Space Vehicle Dept.

CROYDON H. HARTLEY, named director of international military sales for the Douglas Aircraft Co.

GEORGE P. SUTTON has returned to Rocketdyne as manager of the newly-created development planning organization of the research and engineering department.

ROBERT A. HAWKINS, appointed director of products in charge of a new Industrial Products Subdivision at the Avco Research and Advanced Development Div.

JOHN W. BUFFINGTON, named assistant to the president of the Grand Central Rocket Co.

WILLIAM H. HEATH, named director of the new Systems Div. at GPL Div., General Precision Inc.

N. W. TILLINGHAST, appointed VTOL engineering manager at Chance Vought.

H. R. DETTWYLER, appointed chief engineer of the Cooper Development Div. of The Marquardt Corp.

WILLIAM L. HILL, appointed manager of the Martin Company's office in Huntsville, Ala.

WILLIAM G. CARLSON, named director of defense and aeronautical projects by Burns and Roe, Inc.

PHILIP H. AUGERSON, appointed vice president of Dyna-Therm Chemical Corp.

JOHN V. SIGFORD, appointed director of planning for the Military Products Group, Minneapolis-Honeywell Regulator Co. DAVID C. GERRISH succeeds Sigford as manager of the Aeronautical Div. facility in Los Angeles.

HARRY S. PACK, appointed director of customer relations at Vertol Div., Boeing Airplane Co.

T. SINGELIS, named vice president of marketing services of the Clearing Div. of U. S. Industries, Inc.

GLENN E. SORENSEN, appointed director of organization planning at Lockheed Electronics Co.

RICHARD W. COOK and JOSEPH P. D'AREZZO elected vice presidents of American Machine and Foundry Co. CASS A. BUDNIK, appointed director of field services and general manager of the Titan Installation and Activation Div. of the American Machine & Foundry Co.

ELMER A. MCBRIDE, named west coast district manager for General Electric's accessory power equipment for aircraft, missiles, space vehicles and marine and ground applications.

RUSSELL LOFTMAN, appointed manager of advanced planning at the Cooper Development Div. of The Marquardt Corp.

M. L. STARY, named manager of the Spacecraft Div. at Aerojet-General Corp. ALFRED J. KOOREY, appointed senior engineer for Aerojet's activities on the Minuteman ICBM at Cape Canaveral.

WLADIMIR REICHEL, named engineering counsel to all divisions of Norden Div., United Aircraft Corp.

SCHUYLER KLEINHANS, named director of advanced research for Douglas Aircraft Co.

DR. JOHN MASON, chief of preliminary design for The Garrett Corporation's AiResearch Manufacturing Company of Los Angeles, has been appointed to NASA's Research Advisory Committee on Nuclear Energy Systems.

DONALD G. SPEYER, named director of contracts of the Bendix Systems division of The Bendix Corp.

ROBERT P. SUMBERG and E. DOUGLAS KENNA, appointed vice presidents at Avco Corporation's Research and Advanced Development Div. DR. JAMES C. KECK, appointed deputy director of Avco-Everett Research Laboratory.

FRANCIS A. WARREN has joined Rocketdyne's Solid Propulsion Operations, McGregor, Texas, as a senior technical specialist.

TED DUNNEGAN, JR., named acting division manager of the Electronics Div. of Temco Electronics & Missiles Co.

HENRY S. RUBENSTEIN, appointed project supervisor, process metallurgy, The Beryllium Corp.

DR. ERNST H. KRAUSE, named director of the new Technical Staff within the Aeronutronic Div. of Ford Motor Co. LELAND C. PLEGER, appointed manager of Marketing and Planning for Aeronutronic's Tactical Weapon Systems Operations.

NORTON C. SATHER, named assistant manager of American Bosch Arma Mississippi Corp.

D. W. HEGE, manager of the Advanced Design subdivision of Rocketdyne, North American Aviation.

William L. Hill
Martin

Dr. John Mason
AiResearch

John V. Sigford
Minneapolis-Honeywell

Wladimir Reichel
Norden Div.

Cass A. Budnik
AMF

Joseph P. D'Arezzo
AMF

William G. Carlson
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WE VACUUM HEAT TREAT

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Production loads of 400 series, AM350, Greek Ascaloy, etc., are heat treated in Ipsen vacuum furnaces with superior physical properties.

The load pictured above is a typical example of 410 stainless screws being heat treated bright by Ipsenlab of Rockford.

Complete facilities are available for pilot or production runs with vacuum processing to 4000°F. Call WOodland 5-8788 in Rockford, or write to let us know how we might serve you.

Ipsenlab OF ROCKFORD, INC.

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Circle 33 on Inquiry Card

SILICONE NEWS from Dow Corning

Photo courtesy Fairchild Engine & Airplane Corporation

Seals Where Others Failed

Fairchild recently supplied several F-27B's to Northern Consolidated Airlines, which serves Alaska and Canada. Trouble started when temperatures dropped below —50 F. Seals caused doors to stick closed. After the doors were opened, seals were so hard the doors couldn't be closed. Silastic®, the Dow Corning silicone rubber, was used to replace the seals for the large cargo and passenger doors. Results: no sticking closed, no jamming open . . . Silastic maintains a positive seal at all altitudes despite the wide variations in temperatures encountered.

Write to Dept. 0310 for information.

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

Circle 34 on Inquiry Card

Wyman-Gordon makes a major
Now parts are being forged in

Nickel-base
high-temperature alloy
45" diameter
520 pounds

BROAD RANGE OF GAS TURBINE COMPONENTS ALSO BEING PRODUCED IN:

- Low-Alloy, High-Strength Steels
- Intermediate-Temperature Alloys
- Titanium and Refractory Metals
- Aluminum and Magnesium

High-strength steel
19" diameter
143 pounds

PHYSICAL PROPERTIES

TENSILE AND YIELD STRENGTHS	ALLOY*	TEST TEMPERATURE °F.	HEAT TREAT	GUARANTEED MINIMUM ULTIMATE TENSILE STRENGTH PSI	GUARANTEED MINIMUM 0.2% YIELD STRENGTH PSI	GUARANTEED MINIMUM ELONGATION %	TYPICAL VALUES ULTIMATE TENSILE STRENGTH PSI	TYPICAL VALUES 0.2% YIELD STRENGTH PSI	TYPICAL VALUES ELONGATION %
	Waspaloy	RT	A	175,000	120,000	15.0	194,000	136,000	24.0
		1000	A	162,000	112,000	13.0	175,000	124,000	23.0
	René 41	RT	B	180,000	132,000	12.0	200,000	150,000	15.0
		1400	B	135,000	115,000	13.0	145,000	125,000	18.0
	Astroloy	RT	C	190,000	138,000	10.0	205,000	152,000	12.0
		1400	C	150,000	122,000	12.0	160,000	132,000	15.0
	U-500	RT	D	175,000	120,000	10.0	195,000	135,000	12.0
		1400	D	125,000	105,000	12.0	140,000	120,000	15.0
	M-252	RT	B	170,000	115,000	15.0	185,000	125,000	20.0
		1000	B	160,000	105,000	15.0	165,000	115,000	22.0

STRESS RUPTURE	ALLOY*	TEMPERATURE STRESS	GUARANTEED MINIMUM	TYPICAL VALUES
	Waspaloy	1350°F.—70,000 psi	70 hours—6% Elongation	130 hours—16% Elongation
	René 41	1350°F.—85,000 psi	30 hours—8% Elongation	60 hours—15% Elongation
	Astroloy	1800°F.—20,000 psi	20 hours—7% Elongation	35 hours—12% Elongation
	Udimet 500	1650°F.—25,000 psi	30 hours—6% Elongation	55 hours—12% Elongation
	M-252	1500°F.—40,000 psi	30 hours—8% Elongation	55 hours—16% Elongation

NOTE: The guaranteed minimums are based upon radial and tangential test locations.

COMPOSITION AND HEAT TREATMENT

CHEMISTRY	ALLOY*	ELEMENTS C	Cr	Mo	Co	Ti	Al	B	Ni
	Waspaloy	.08	19.0	4.3	13.5	3.0	1.4	.004	Balance
	René 41	.08	19.0	10.0	11.0	3.1	1.6	.004	Balance
	Astroloy	.05	15.0	5.0	15.0	3.5	4.3	.030	Balance
	Udimet 500	.07	18.5	5.0	18.3	3.0	3.0	.003	Balance
	M-252	.15	20.0	10.0	10.0	3.0	1.3	.002	Balance

HEAT TREATMENT		
	A.	1850°F.—4 hours—OQ; 1550°F.—2 hours—AC; 1400°F.—16 hours—AC
	B.	1950°F.—4 hours—AC; 1400°F.—16 hours—AC
	C.	2100°F.—½ hour—AC; 1400°F.—16 hours—AC
	D.	1975°F.—4 hours—AC; 1500°F.—24 hours—AC; 1400°F.—16 hours—AC

NOTE: Refer to appropriate heat treat code in Tensile & Yield Strength table.

*Waspaloy: Pratt & Whitney Aircraft Corp.; René 41, Astroloy and M-252: General Electric Company; Udimet 500: Metals Division, Kelsey-Hayes Company.

contribution to gas turbine progress . . . these new Superalloys with Guaranteed Minimum Properties

permits designing to higher operating stresses . . . increased efficiency . . . greater component reliability for every gas turbine application

Rapid progress in developing the gas turbine has materially extended application of this prime power source to areas other than aircraft. Significant contributions in forging techniques and metallurgical advancements by Wyman-Gordon have in part made this possible.

Now designers are free to explore new frontiers of turbine performance unhampered by former material limitations. The high temperature alloys shown here exhibit outstanding tensile and stress rupture strengths in elevated temperature environments. These alloys have been forged into discs, shafts, rings, blades and vanes on a production scale.

Wyman-Gordon offers these alloys to *guaranteed minimum properties* for such vital components. This is made possible by the broad experience in forging parts from all difficult-to-work materials, including a complete range of low-alloy, high-strength steels; intermediate-temperature alloys; light metals; titanium and the refractory materials.

Our metallurgists and forging engineers are prepared to counsel on turbine components . . . evaluating material requirements and forging of existing designs and development parts. For assistance or additional information on Superalloy forgings, write—Product Manager, Turbine Applications, Wyman-Gordon Company, Worcester, Massachusetts.

WASPALOY

RENÉ 41

ASTROLOY

UDIMET 500

M-252

MEETING DESIGNERS' NEEDS IN EVERY TURBINE APPLICATION

- Aircraft and Missile
- Nuclear Power and Propulsion
- Rail and Highway Transport
- Power Generation
- Air Supply and Pumping
- Pipeline Boosting
- Auxiliary Service
- Automotive
- Marine Propulsion
- Stationary Power

EST. 1883

FORGED

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WYMAN-GORDON

FORGINGS

of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

HARVEY ILLINOIS — WORCESTER MASSACHUSETTS — DETROIT MICHIGAN

GRAFTON MASSACHUSETTS — LOS ANGELES CALIFORNIA — PALO ALTO CALIFORNIA — FORT WORTH TEXAS

Worth Asking For

Pressure Gage

Flyer summarizes features of fused quartz pressure gage system. — *The Buck Instrument Co.*

Circle 83 on postcard for more data

Converter

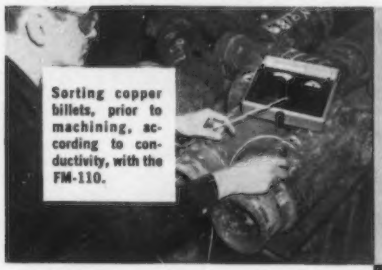
Flyer gives tentative specs on high voltage DC-to-DC converter.—*Transformer Electronics Co.*

Circle 84 on postcard for more data

New fully portable ALL-TRANSISTORIZED BATTERY-POWERED

ELECTRICAL CONDUCTIVITY METER

Now you can use conductivity instantly to measure hardness, alloy content, sort mixed materials,— on practically ANY NONMAGNETIC METAL.



Sorting copper billets, prior to machining, according to conductivity, with the FM-110.

Use on:

ALUMINUM
STAINLESS STEEL • COPPER •
MAGNESIUM • BRASS • BRONZE
• LEAD • SILVER or other
nonmagnetic metals . . .
• INGOTS • SHEETS • BARS
• FINISHED PARTS

EVALUATE material alloy, hardness, uniformity of heat treat, as directly rated to conductivity

SORT mixed nonmagnetic metals

MEASURE ABSOLUTE CONDUCTIVITY of electrical hardware and components

CHECK AGING OF ALUMINUM ALLOYS — 100% at high speed

TEST TENSILE STRENGTH OF aluminum by conductivity

MEASURE COATING THICKNESS and clad side of sheets

ALSO TO: determine phosphorous content in copper, measure thermal conductivity as function of electrical conductivity, detect fire damage to aircraft surfaces and structures by change in conductivity in heat-affected zones.

the MAGNATEST* FM-110

$875.00 Complete

F. O. B. our plant, Chicago. Local, sales or use tax extra. Continental U.S.A. and Hawaii only. Price subject to change.

- Weighs only 4½ lbs.
- Accuracy proved in service to better than ±3% of scale reading.
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New, practical, money-saving uses for the FM-110 are being found continuously. Where can it help you? Phone our local field engineer or write Magnaflux Corporation, 7326 W. Lawrence Ave., Chicago 31, Illinois.

*Magnatest is a registered U.S. Patent Office trade mark of Magnaflux Corporation for its electrical instruments for testing metallic and conductive objects. THE FM-110 is based upon designs of Institut Dr. Foerster, Reutlingen, Germany.

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General Mills TEST SYSTEMS

Gyros

A 44-pg. illustrated booklet on types and applications of gyros.—*Kearfott Div., General Precision Inc.*

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Explosive Ordnance

Bulletins describe "Pyrindicator" for testing electro-explosive circuits, and safe/arm initiator for missiles.—*McCormick Selph Associates.*

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Environmental Testing

Brochure gives data on environmental testing and other applications for controlled atmospheric conditions. —*Webber Manufacturing Co.*

Circle 87 on postcard for more data

Ultrasonic Cleaning

Guide to ultrasonic cleaning.—*Powertron Ultrasonics Corp.*

Circle 88 on postcard for more data

Welding Equipment

Catalog shows line of stored-energy, capacitor-discharge power supplies, precision welding heads and handpieces, and welding accessories.—*Weldmatic Div., Unitek Corp.*

Circle 89 on postcard for more data

Beta Titanium

Full, illustrated data on Beta-titanium alloy Ti-13V-11Cr-3Al, providing burst strength to density ratios exceeding one million. — *Titanium Metals Corp. of America.*

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Dynamic Digital Logic

Proceedings of the First User's Conference on Dynamic Digital Logic. Papers from Space Technology Labs and Jet Propulsion Lab.—*Computer Control Co.*

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Solid Lubricants

Booklet describes molybdenum disulfide solid lubricants.—*The Alpha-Molykote Corp.*

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LORAC

Brochure fully illustrates Lorac electronic positioning systems and services.—*Seismograph Service Corp.*

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World Trade

"The Story of World Trade," a 32-page, illustrated booklet.—*E. I. du Pont de Nemours.*

Circle 94 on postcard for more data

Electronics Purchasing

Survey of attitudes of purchasing agents in the electronics industry to determine their preferences between manufacturer's representatives and factory salesmen.—*Industrial Market Research Associates.*

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Numerical Control

"Power in Numbers—the How and Why of Numeric Control."—*Norden Div., United Aircraft Corp.*

Circle 96 on postcard for more data

Dust-free Areas

Folder on requirements for ultra-clean facilities.—*Environmental Div., Shielding Inc.*

Circle 97 on postcard for more data

Doppler System

Illustrated guide to operational use of new doppler navigation system.—*GPL Div., General Precision, Inc.*

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Fusion Welding

Booklet, "A Pictorial Report of Sciaky Developments in Highly Precise, Fully Automatic Fusion Welding Equipment."—*Sciaky Bros., Inc.*

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Bendix

Brochure gives firm's history, present activities.—*The Bendix Corp.*

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Power Systems

Bulletin on electrical power systems for missiles, satellites and space vehicles.—*General Electric Co.*

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Superbolts

Bulletins on new 900°F superbolts, nuts.—*Standard Pressed Steel Co.*

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Free Space Rooms

Handbook shows how to select best design for free space room (or anechoic chamber). Includes photos and diagrams.—*McMillan Industrial Corp.*

Circle 103 on postcard for more data

Vigilant

Booklet shows uses, design, operating principles of the Vickers "Vigilant" anti-tank missile. — *Vickers-Armstrongs (Aircraft) Ltd.*

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Litton Industries

Illustrated profile of firm.—*Litton Industries.*

Circle 105 on postcard for more data

Ceramic Products

Brochure shows ceramic products, production techniques. — *Gladding, McBean & Co.*

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Thrust Measurement

Booklet gives complete presentation of factors in design of high-accuracy rocket thrust stands and calibrators.—*Wiancko Aeronautics.*

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Reliability

Eight-page article "Achieving Reliability Through Integrated Quality Control."—*General Electric Co.*

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Space Age Metals

Booklet describes properties of 16 high purity rare-earth metals.—*The Lunex Co.*

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Reduction Drives

Brochure explains how "Hi-Range" speed-reduction drive works. —*Black Tool Inc.*

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Oscillography

Booklet shows how direct-recording oscillograph is applied in the missiles and aircraft industry and commercially.—*Heiland Div., Minneapolis-Honeywell.*

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Tubing

Bulletin shows how firm's tubing is applied in aircraft, missiles, and rockets.—*Superior Tube Co.*

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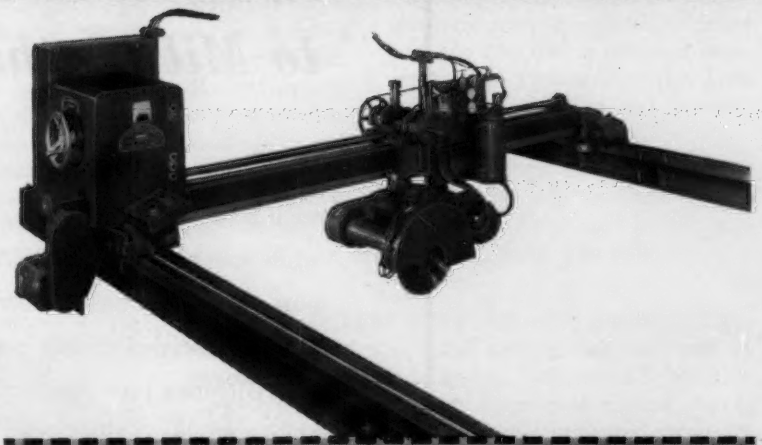
Servo Components

Fully-diagrammed 56 pg. text on servo components and their use in systems.—*Kearfott Div., General Precision Inc.*

Circle 113 on postcard for more data

ECONOMY SAW CUTS SHEET STOCK WITH 4-WAY ACTION



Accurate Squares up to 10 ft. Wide
Any Length — Cuts Metal or Plastics

The new Ty-Sa-Man Economy "111-CX" produces accurate square rectangles up to any length, and up to 10 feet wide, from stock up to two inches thick. Motor and arbor travel on a transverse rail, which moves along two side rails. This four-way movement, in combination with the 90 degree swivel head, permits trimming all four sides of a plate without moving it. Handling time is reduced to a minimum.

Ty-Sa-Man
SINCE 1885

Write for FREE BULLETIN
TY-SA-MAN Machine Co., Inc.,
1135 White Ave., Knoxville, Tenn.

Ultradex high precision indexing table

"In-Process" Inspection to Millionths

Inspecting a workpiece with laboratory accuracy while mounted in machining position greatly reduces scrap in high precision missile components. The Ultradex provides this checking ability while, at the same time, serving as a machining fixture. The Ultradex has a radial locating and indexing accuracy of ¼ second of arc, or six millionths of an inch at a one-foot diameter. Table surface is flat and parallel within 0.000050 inches. Large 12″ diameter with ample radially dispersed threaded holes permits easy attachment of workpieces or fixtures. Sealed design allows use in operations requiring coolants or lubricants.

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Booth 240, 1960 ASTME Western Engineering Conference and Exhibit.
Los Angeles, November 14 through 18.

Industry Notes

INSIDE SUEL

The Sergeant second generation missile is in production at Sperry Utah Engineering Laboratory (SUEL). Design of this solid propellant inertially-guided tactical missile is based on stringent environmental requirements. Hence an important part of SUEL is its environmental lab, where all electronic, electrical and electromechanical assemblies are tested.

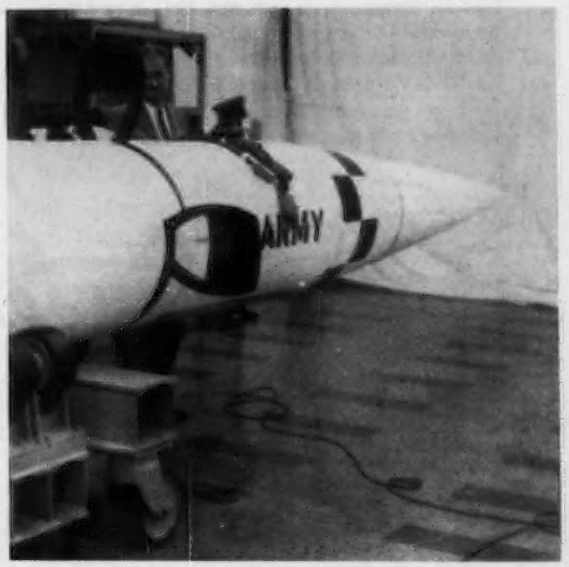
All assemblies undergo flight acceptance tests simulating aerodynamic temperature and vibration stresses.

Sample assemblies are also given type approval checkout in all possible tactical environments (Sergeant is to replace Corporal in troop use). These tests include transportation vibration, shock, transportation altitude, sand and dust, salt spray, rain, storage temperature, humidity, fungus, operating temperature, static acceleration, operating vibration and operating altitude.

Rundown of unclassified equipment used at this Salt Lake City facility of Sperry Rand:

- C-200A "MB" shaker producing 25,000 lb vibration force. Shaker mounted on an isolating 220,000 lb "floating" concrete pad, is actually a giant radio loudspeaker. It subjects components to random noise far above anticipated levels. Sperry says "many thousands of hours" were spent in engineering effort to develop each component capable of surviving this test.
- 300-channel data acquisition system, computing and reducing information for evaluation in seconds.
- Hyge shock machine producing 40,000 lb thrust. This produces the shocks encountered during handling, transportation or storage.
- Cone-shaped, polished-reflector heating fixture constructed of thin-gauge aluminum. Internal rings suspended by standoff insulators form power connections or buss bars for 234 quartz infra-red heating lamps. Fixture simulates both aerodynamic heating and pressure loads.

Test firings and field environmental exercises are now taking place. The Army calls missile performance highly successful.



INFRARED TEST FIXTURE (left) dissipates 750,000 watts at double rated voltage; final checkout of warhead and guidance system (below) takes place in assembly area. In heat tests, Sergeant nose cone is evacuated and then collapsed by heat pressures which are more than 300 per cent beyond anticipated aerodynamic environment. Note hydraulic-actuated drag brakes near guidance section.

Just One Squeeze with IDEAL's New "Custom Stripmaster" Removes Teflon* and Other Hard-to-Strip Insulations

To help prevent wire nicking and insulation damage, these new IDEAL "Custom Stripmasters" are precision drilled on watchmaker's equipment.

With Ideal's new Custom Stripmasters, a light squeeze on the handles strips any wire completely clean and bare up to a full ⅞ inch.

To help prevent nicking and scraping of wires, the Custom Stripmaster's matched sets of blades are precision drilled on watchmaker's equipment to the exact wire sizes. Counterbored blades ride on cut insulation to prevent scratching of stripped wire. Jaws grip wire firmly to prevent insulation damage. 3 models available. Wire sizes from No. 10 to 30.

*Reg. Trademark of DUPONT

Custom Stripmaster® Patented, No. 2,523,936 by IDEAL

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TA Cases come in a diversity of standard lid sizes, and are sold at proprietary prices. During assembly the depth can be cut to your exact specifications. Or, if you like, TA will furnish you free vellums and templates so you can save yourself money by designing your product to fit one of the many standard sizes.

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Designed primarily for shut-down or shut-off application, this unit is used in pumping plants, irrigation systems, fire control on rocket test stands, municipal water systems, etc. Of the water interface type, the Pulsco swirl principle reduces pressure and reduces shock and surge resulting from kinetic energy within the pipeline, this by compressing gas within the chamber and by friction through the swirl chamber.

Guaranteed not to recycle, this Pulsco Spherical Shock Trap is built for pressures to 200 PSIG and up. Sizes from 34 to 102 inches diam.

PULSCO *Bellows* SHOCK TRAP

For AIRCRAFT AND MARINE FUEL LOADING SYSTEMS JET FUEL AND GASOLINE

Take the "hammer" out of high velocity fuel lines — removes the danger of broken lines, meters, and overstressed loading equipment. Assure correct meter readings consistently with this Pulsco scientifically designed Bellows Shock Trap — the best for quick STOP and GO liquid lines.

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Industry Notes

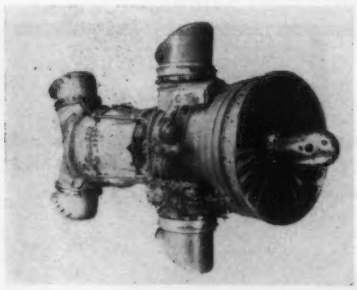
. . . continued from page 73

New VTOL Ducted Fan

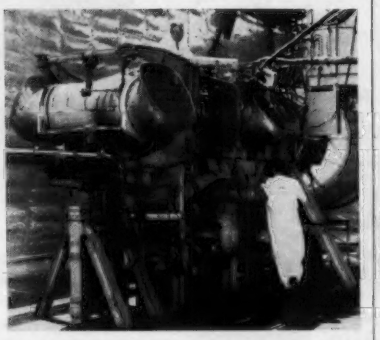
The Bristol Siddeley BS 53 lift/thrust ducted fan is designed around two shafts which revolve in opposite directions. One shaft holds the fan; other holds a high pressure compressor. This feature reduces the resultant gyroscopic couples due to precession.

Swivelling outlets allow thrust to be directed downwards, forwards or backwards. Unit has been selected for use in the Hawker P.1127 VTOL support fighter.

Bristol Siddeley is working on another new ducted fan called the BS 75. This has 7350 lb thrust and is for use in short haul airliners rather than VTOL.



◀ **MOVABLE JET NOZZLES** are outstanding feature of BS 53 lift-thrust ducted fan. Entire thrust can be directed down, back, forward or in intermediate direction.



NEW ENGINE shown on test rig at Bristol Siddeley's Patchway works. It will power Hawker P1127 VTOL fighter.

Minuteman T.V.C.

A new type of thrust vector control nozzle is expected to be ready for flight test on the solid-propellant Minuteman this year.

The large movable nozzles represent an advance both in materials and engineering design. All three stages of Minuteman work successfully with them.

The nozzles are a combination of high temperature metal alloys and various plastics. They must survive severe environmental conditions including 5700°F temp at throat. Nozzles are lightweight and controllable, resulting in significant weight-savings. Without them, heavy auxiliary power units would have been required. Thrust will be terminated at command of guidance system.

Project Apollo

Plans call for design, development and manufacture of NASA's Apollo advanced manned spacecraft in the 1962-65 period. Active flight tests and missions with the Saturn booster would come in the 1965-70 period.

Program, now in the study phase, is to bring about a craft which could carry several men in orbits lasting several weeks. Its multimission capability will include a variety of scientific, technological and civilian services. It is also proposed as an intermediate step towards manned space stations and manned reconnaissance flights near the moon.

NASA will award several fixed fee six months study contracts Nov. 14.

Your complete guide to the *new* language of space exploration

AEROSPACE DICTIONARY

by Frank Gaynor

with an introduction by Wernher von Braun

As man probes further into space, a vital new language comes swiftly into being. This up-to-the-minute reference work answers the needs of the student and general reader, as well as those in government and industry who require a knowledge of the essential terminology in space exploration.

Thousands of clear, concise entries, alphabetically arranged, present the most authoritative information on the language of rocketry and astronautics, guidance systems, satellites, telemetering devices, manned space flight, re-entry phenomena, celestial mechanics and aeronautic science.

The dictionary's editor, *Frank Gaynor*, had the assistance of the United States Department of Defense as well as civilian agencies and research centers in preparing the book's entries. America's most distinguished authority on rocketry and space travel, Dr. Wernher von Braun, has also assisted in the work's preparation and contributed a provocative introduction "The Why of Space Travel."

AD-6

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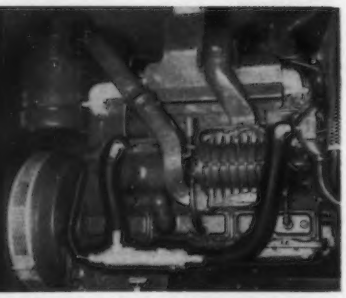

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Electric Pre-Heater for Diesel and Gasoline Engines

Industrial engines kept warm between operating periods, ready for instant action. KIM prevents cold weather damage; reduces wear and costly down-time. KIM plugs into an electric circuit; draws off cold water from engine; heats and circulates it through engine. Approved and used by all major engine manufacturers.

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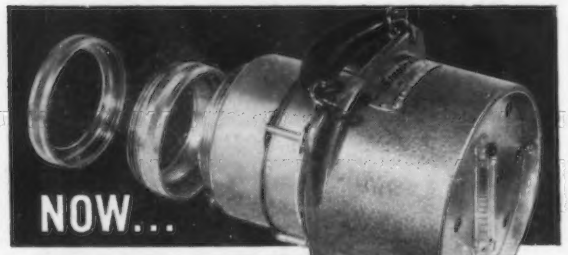

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Industry Notes

. . . continued from page 75

POLARIS PICTURES

POLYURETHANE FOAM fills void in double-walled missile tube doors on Polaris subs. Foam helps protect missile from sea, also cuts costs and weight. It is made by General Latex.

FIRING CHAMBER housing Polaris consists of inner and outer tube. Photo in ship motion simulator shows hardware portion of inner tube which projects above deck. This portion is filled with polyurethane foam.

END CLOSURES for Polaris rocket chambers leave Ordnance Div. Labs of Aerojet General. Closures are explosively formed from flat blanks of high strength steel.

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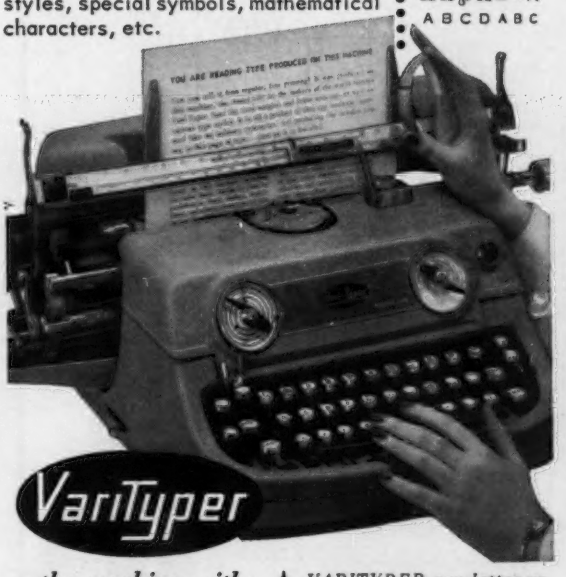

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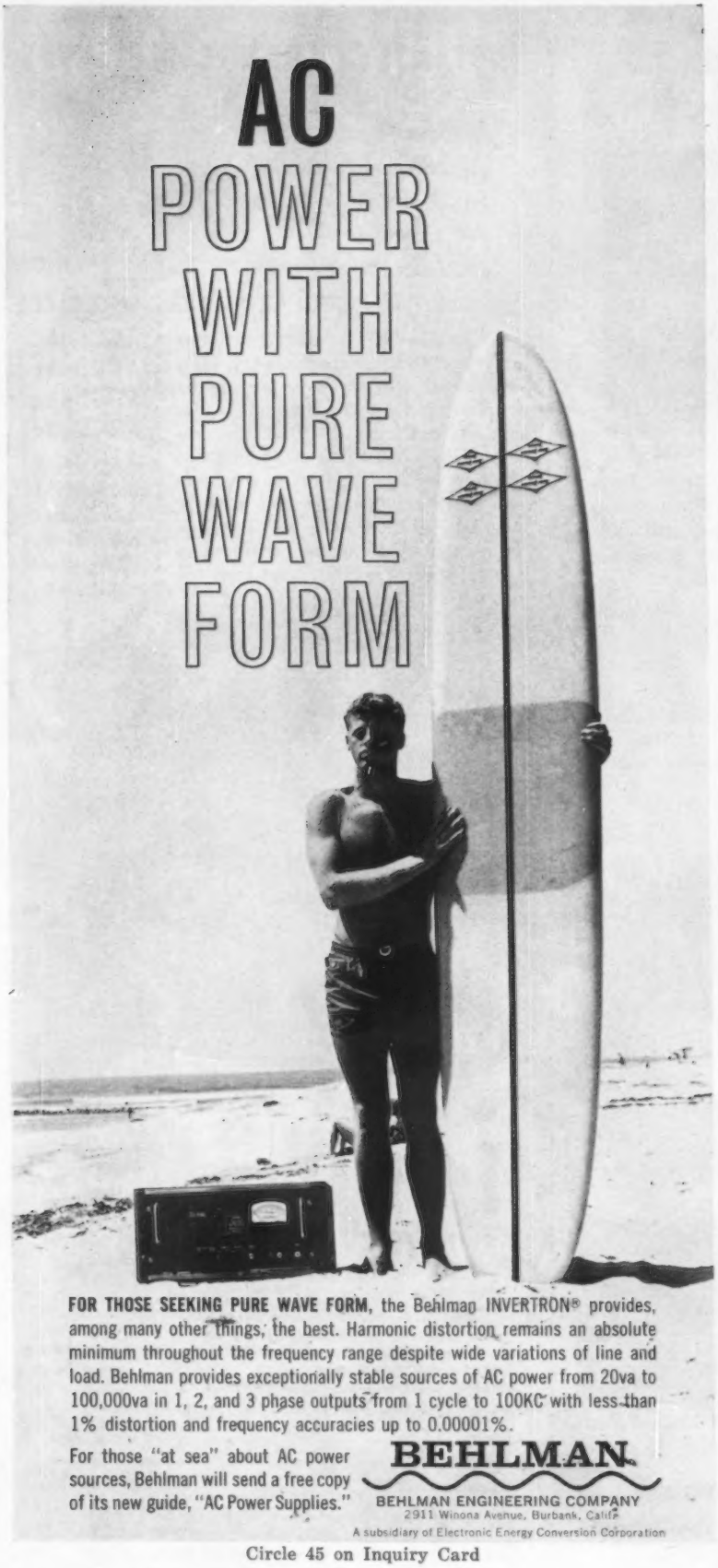

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For those "at sea" about AC power sources, Behlman will send a free copy of its new guide, "AC Power Supplies."

BEHLMAN

BEHLMAN ENGINEERING COMPANY
2911 Winona Avenue, Burbank, Calif.
A subsidiary of Electronic Energy Conversion Corporation

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Industry Notes

. . . *continued from page 77*

R & D Briefs

Terrain study of the moon by the Interior Department's Geological Survey has been published by the Army Engineers. Title: "Engineer Special Study of the Surface of the Moon."

"The Phoenix," new two-stage research missile, is now in use for ionosphere studies. Developer-producer: Rocket Power/Talco Div., The Gabriel Co.

Rolled beryllium structural shapes are object of Air Force contract to The Beryllium Corp. Firm will work on techniques for mill rolling and hot extruding into shape.

Algae experiments have supported a mouse for 66 days at Chance Vought. Oxygen was supplied by algae, which also kept chamber free from carbon monoxide.

J93-3 flight testing is being speeded by ground data processing center at Edwards AFB. System supplied by Radiation Inc., uses Pulse Code Modulation.

Production Techniques

Gold plating on Discoverer capsules provides maximum heat reflectivity and emissivity. Plating: "Sel-Rex Bright Gold" from Philadelphia Rust-Proof Co.

Shaw Process for precision castings will be used by Vanadium-Alloys Steel Co., which recently completed a licensing agreement with Shaw Process Development Corp.

Fused silica casts for brazing complex contoured stainless steel honeycomb panels have been successfully tested at Boeing-Wichita. New concept will often eliminate costlier use of machined graphite fixtures which permitted only simple contours. Cast can be used repeatedly at production rates.

CAN YOU GUESS

The Rupture Pressure Of A ¼" Rupture Disc Made From This Paper-Thin Piece Of Stainless Steel By BS&B?

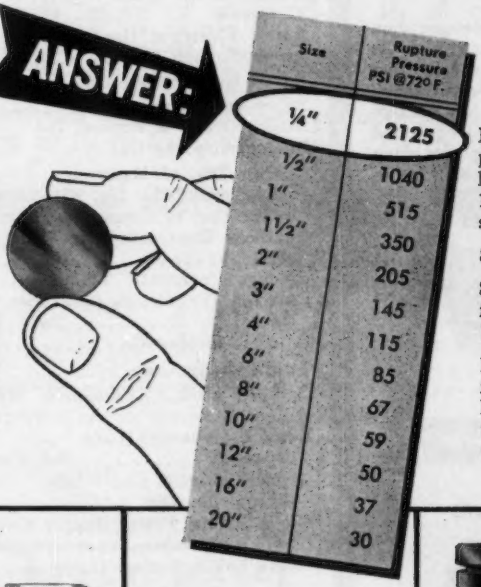
Rupture Disc Metals

Aluminum	Platinum	Nickel
Silver	Stainless	Monel
Copper	Inconel	

Rupture Discs are performing a wide variety of pressure relief and actuation functions on many of today's most advanced aircraft, missiles, rockets and submarines.

Here we show a few of these functions to illustrate the versatility of the rupture disc's basic principle in application and design. Perhaps one of them will suggest an answer to your pressure control requirements.

ANSWER:



Pressure as low as 5 psi can be attained in large diameters; up to 100,000 psi in small sizes.

Sizes from ⅛ inch up.

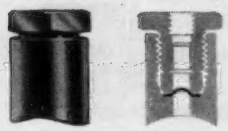
Service temperatures from sub-zero up to 1000° F.

BS&B will design and fabricate any device to hold the rupture disc to your space and weight specifications.

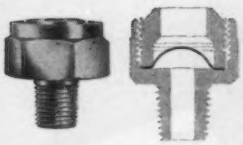
Rupture disc in larger fitting restrains the thrust of a "Jato Bottle" until the ignited propellant develops a specified pressure. When the desired thrust value pressure is reached, the disc ruptures to provide instantaneous exhaust and resultant thrust. Disc in the small fitting is a safety device for overpressure relief.

Rupture disc in this fitting is used in underwater service. At a specified pressure the disc ruptures to actuate a trigger mechanism.

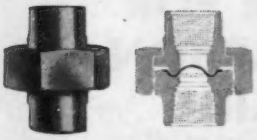
This device fits in the outer shell of a vacuum insulator vessel containing a fuel component. The rupture disc protects against dangerous pressure build-ups which might occur if the inner shell should break or leak.



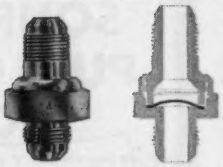
This rupture disc fitting is used on seat ejection mechanisms to lessen shock by the dissipation of excess thrust pressure.



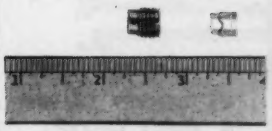
This disc assembly is used to protect against overpressure in air conditioning systems of commercial aircraft.



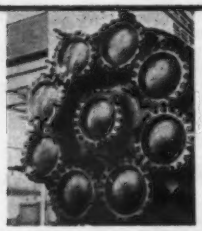
Here a rupture disc serves as a vital component in power supply of nuclear powered submarine.



Simultaneous rupture of the discs in two of these fittings triggers the mixing of a fuel and oxidizer.



Rupture disc in this tiny fitting protects against overpressure in a missile's hydraulic control system.



Large diameter (24") Safety Heads are fitted in manifold to provide overpressure protection on this engine test chamber.

BS&B — ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

May we suggest further investigation of rupture disc applicability to your pressure control requirements? For engineering consultation call or write...

BLACK, SIVALLS & BRYSON, INC.

Safety Head Division, Dept. 2-GC10
7500 East 12th Street
Kansas City 26, Missouri

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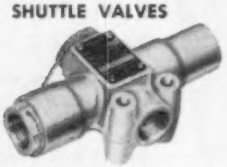

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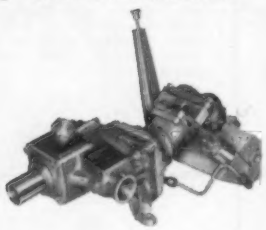

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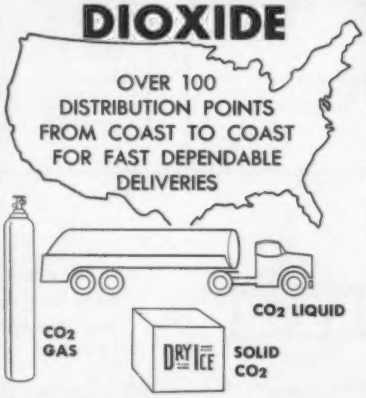

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....1. Management
....2. Design & Engineering
....3. Production
....4. Procurement

B. Type of Plant or Facility

....1. Airframe
....2. Propulsion
....3. Electronic Systems & Parts
....4. Mechanical Systems & Parts
....5. Raw & Processed Material
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....7. Military & Government Facilities
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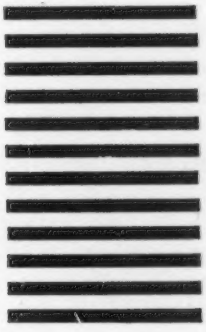

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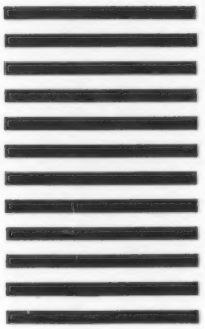

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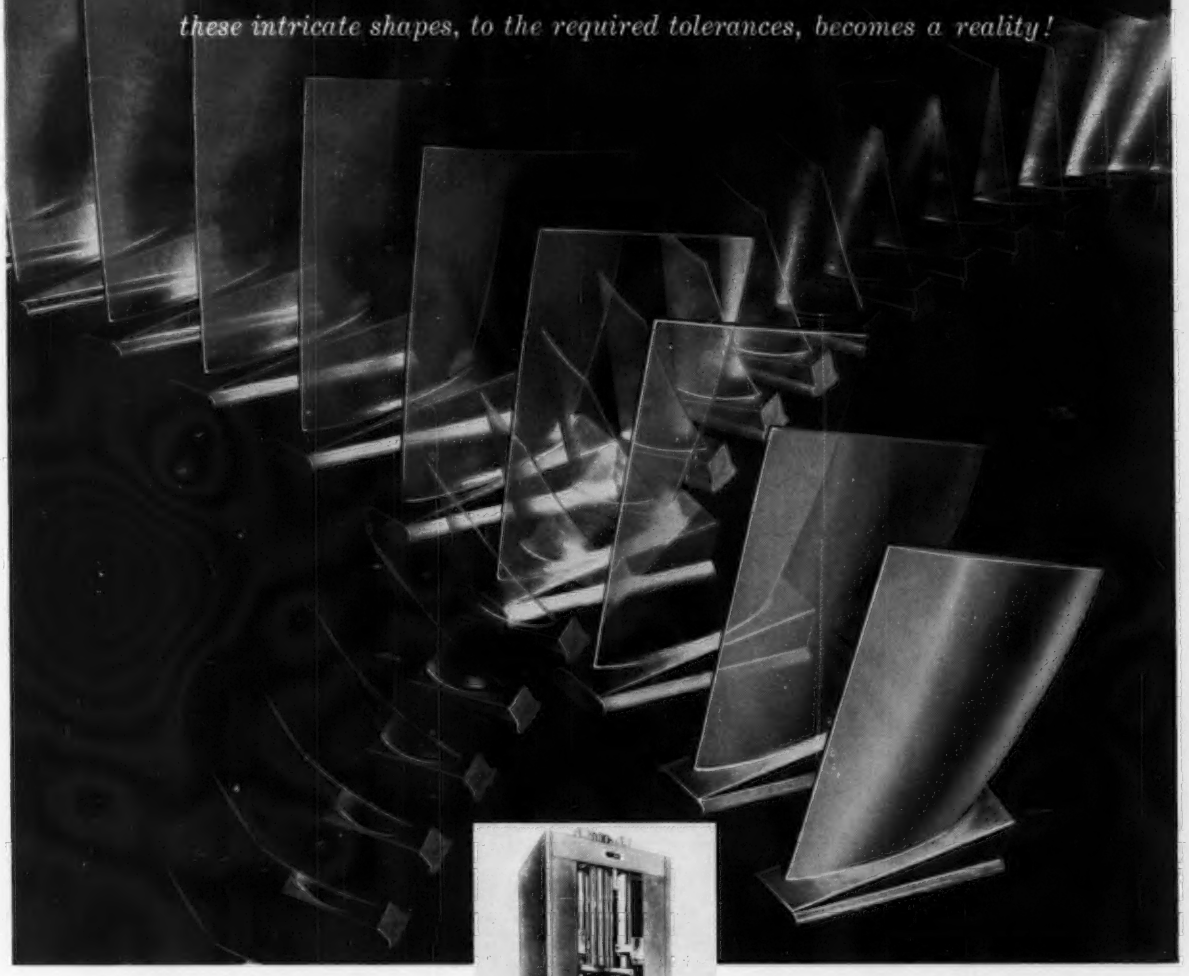
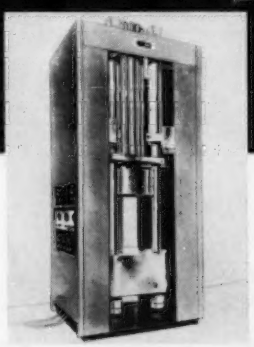
STRENGTH

in jet engine turbine blades

Strength of turbine blades is a primary factor in the output and performance of jet engines. Since the inception of the jet age, engine builders have agreed that forged blades would offer greater strength. Now, with DYNAPAK, forging these intricate shapes, to the required tolerances, becomes a reality!



Turbine blades forged by DYNAPAK are now being tested by a major aircraft engine builder. Among the already obvious advantages: thin edges, superior grain flow, lower cost, and greater strength. And the use of multi-cavity dies holds promise of even lower costs to come!



DYNAPAK is industry's first high-energy-rate machine tool for forging, forming, compaction, and extrusion. This DYNAPAK machine (left), installed at Precision Forge Co., Santa Monica, California, is today producing turbine blades. DYNAPAK invites your inquiry, and an opportunity to solve your production problems.

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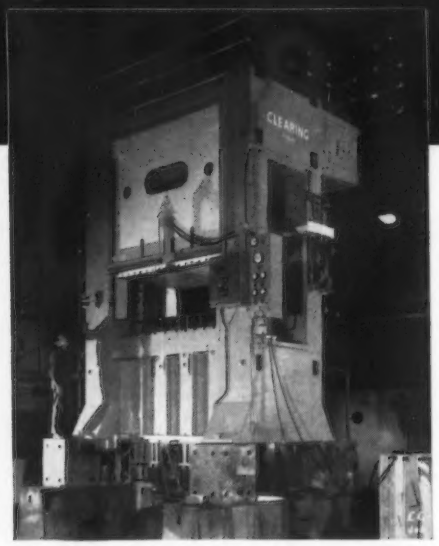
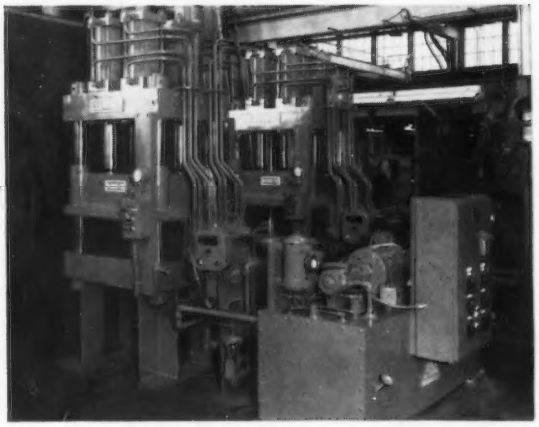


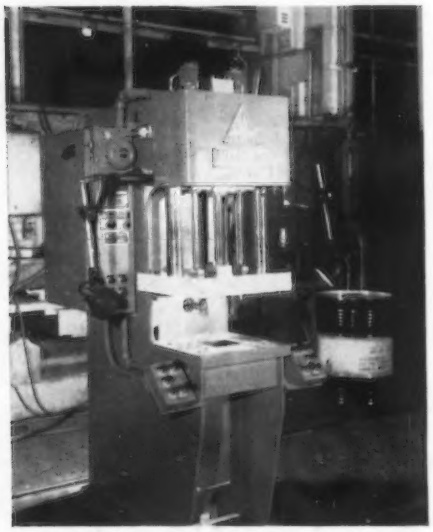
HEATING & AIR CONDITIONING PARTS—*FORMED*

Sheet metal parts are drawn on this 750 ton press designed to handle off-center loads with blank and draw dies using individually controlled cushions.



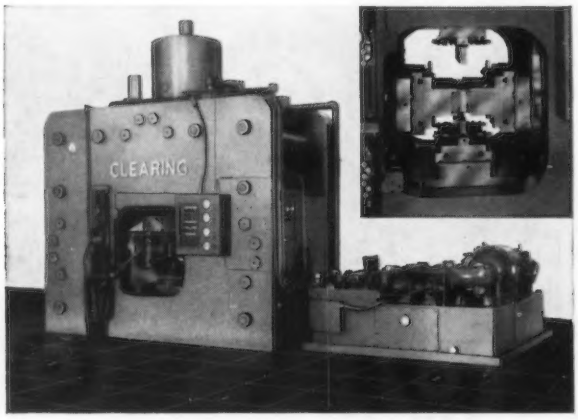
BOWLING BALLS—*MOLDING*

These two steam heated, 200 ton column-type hydraulic presses are designed for multiple cavity molding and operated from a single power source.



DIE CASTING—*TRIMMING*

High speed trimming is done on this 10 ton hydraulic gap press.



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